CANADIAN JOURNAL OF RESEARCH

VOLUME 26 JUNE, 1948 NUMBER 3

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NATIONAL RESEARCH COUNCIL
OTTAWA, CANADA

CANADIAN JOURNAL OF RESEARCH

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The *Canadian Journal of Research* is published by the National Research Council of Canada under authority of the Chairman of the Committee of the Privy Council on Scientific and Industrial Research. The *Canadian Journal of Research* is edited by a joint Editorial Board consisting of members of the National Research Council of Canada, the Royal Society of Canada, and the Chemical Institute of Canada.

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Canadian Journal of Research

Issued by THE NATIONAL RESEARCH COUNCIL OF CANADA

VOL. 26, SEC. C. JUNE, 1948 NUMBER 3

A STUDY OF THE MYCELIUM AND HAUSTORIA OF THE RUSTS OF *ABIES*[1]

BY LILLIAN M. HUNTER[2]

Abstract

A study of the mycelium and haustoria of certain rusts of *Abies* has been made. It was found that the mycelium of three rusts have distinguishing characteristics. The haustoria of *Melampsorella Cerastii*, *Hyalopsora Polypodii* and *Milesia polypodophila* are so distinctly characteristic as to serve as diagnostic criteria for the species. The haustoria of six *Uredinopsis* species are similar in type; those of two species of *Pucciniastrum* are of the same type. The haustoria of *Calyptospora Goeppertiana* are hyphal and very slender. The relation of the haustoria of the rusts, up to near maturity, is one of high symbiotic nature in *Abies balsamea*. The haustoria of *Milesia polypodophila* and certain other rusts in their aecial hosts show a contrast in type to the haustoria in their telial hosts. The haustoria of *Milesia Scolopendrii* and *M. vogesiaca* are hyphal or of loose spiral form. The haustoria of *M. Kriegeriana* resemble those of *M. intermedia*. The haustoria of *M. Polypodii* are usually characteristically branched, serving as an aid in identification. Haustoria were found to occur in the leaves of 19 species of the Pucciniastreae on *Abies*. Eighteen of these are described in the aecial host for the first time.

Introduction

Interest in the occurrence and nature of haustoria in the Uredinales has been growing gradually since DeBary (1) discovered the haustoria of *Melampsorella Caryophyllacearum* (*Aecidium elatinum*) on its systemic mycelium in the stem of *Abies pectinata*. Schroeter (21) made a search for haustoria in the same species on its telial host in 1874, but did not succeed in finding any. He described hyphae with short disclike swellings on the ends and stated definitely that the hyphae twist around the parenchyma cells tightly, pressing but not going inside them.

Sappin-Trouffy (19), in 1892, examined the mycelium and found haustoria in a single species for each of the genera *Puccinia*, *Uromyces*, and *Coleosporium*. He (19) expressed his intention of later giving a description of the haustoria for all the species he had met with and stated: "ils nous suffisait ici d'établir l'existence générale de ces organes dans la famille des Urédinées". In 1896 Sappin-Trouffy (20) described haustoria for nine species in a number of genera of the Uredinales.

Magnus (11), as early as 1899, described complicated haustoria for *Melampsorella Caryophyllacearum* Schroet. in the telial host. In 1901 he (12) stated

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[The April issue of Section C (Can. J. Research, C, 26: 109-217. 1948) was issued June 16, 1948.]

that he had never been able to observe haustoria for *Milesia Kriegeriana* (Magn.) Arth. (*Melampsorella Kriegeriana* Magnus) (12) on the telial host, and in 1902 he (13) made a similar statement in connection with *Milesia Feurichii* (Magnus) Faull (*Melampsorella Feurichii* Magnus) (13). Magnus, in 1892, described the haustoria of *Hyalopsora Polypodii* (Pers.) P. Magn. In the same year he (9) reported that he had observed no haustoria on the mycelium of *Uredinopsis filicina* (Niessl.) P. Magn. Again in 1904 he (14) stated that the mycelium of the *Uredinopsis* species that he had studied is strictly intercellular and bears no haustoria. Faull (6) in an address presented before the International Congress of Plant Sciences, Section of Mycology, Ithaca, N.Y., Aug. 20, 1926, reported the finding of haustoria in the genus *Uredinopsis* for the aecial hosts by the writer, and for the telial hosts by Moss. Moss (16) described haustoria for *U. Atkinsonii*, *U. Osmundae*, and *U. Phegopteridis* in the telial hosts. Faull (6) also reported the finding, by Moss and the writer, of the haustoria of a number of other species in many of which they were noted for the first time. The writer's investigations of the haustoria have been continued and extended to a study of 19 species of the Pucciniastreae.

Material and Methods

The material from which the sections of *Uredinopsis macrosperma* were made was obtained from the herbarium of the Department of Botany, University of Toronto, and was originally collected in the Western States. The European material of *Melampsora Abieti-Capraearum* and *Hyalopsora Polypodii* was obtained from Switzerland through Dr. Eugène Mayor. The rest of the material, with one exception, *Melampsorella Caryophyllacearum*, was obtained from culture experiments. These were supplemented by field collections.

The work of collecting and culturing most of the material was directed by Prof. J. H. Faull, who was assisted by his students, Dr. G. D. Darker, Dr. W. R. Watson, Dr. E. H. Moss, Dr. E. Bensley, and the writer; *Milesia Scolopendrii*, *M. Polypodii*, *M. vogesiaca*, and *M. Kriegeriana* were cultured by the writer in England. Culture experiments also made by the writer were carried on at the University of Toronto with the purpose in view of obtaining young spermogonial material of *Melampsora Abieti-Capraearum;* those carried on by the other students, above mentioned, were made in the Timagami Forest Reserve. All the material examined was of infected leaves of *Abies*, except in the case of *Milesia polypodophila*, in which the stem, as well as the leaves, was examined for mycelium and haustoria.

The fixatives used were the same as those named by the writer (8) in connection with a study of the spermogonia of the rusts of *Abies*, except that form-acetic-alcohol was added to the list.

The preparation of the material, with one exception, was also similar, and the same stains were used as those listed by the writer in (8). The exception referred to was in the treatment of the stem of *Abies* in which the mycelium of *Milesia polypodophila* is systemic. This species presented a problem in that there was difficulty in showing clearly the entrance of the haustorium into the cells of the cortex in the stem. Infected stems with leaves attached were fixed in medium chrom-acetic solution, treated in the usual manner, and embedded in celloidin. Sections of 7μ to 15μ in thickness were made by the use of the sliding microtome. The sections were taken through the usual grades of alcohols, the celloidin was dissolved, and the sections were then led, in graded solutions from 95% alcohol or 70% alcohol, to a lactophenol solution. Stains of acid fuchsin, cotton blue, and light green, each dissolved separately in lactophenol, were prepared. The amount of stain used in each case was just sufficient to give a deep color to the lactophenol. The clear solution of lactophenol applied to the section was drained off, and each of the three stains was applied separately to the sections of the diseased woody stem and leaf. The application was made by means of a pipette. The sections, covered by a bell jar for protection, were allowed to stand overnight. On the following morning the stains were removed by washing with a clear lactophenol solution. Very little color was left in the last solution and the objects were mounted with cover glasses. Preliminary examinations showed the sections thus treated to be promising for study, so in a few days after some evaporation had taken place the slides were 'ringed' with amber cement and put aside. When the cement had hardened the sections were examined under an oil immersion lens. The trial method proved satisfactory. The haustoria stood out more clearly than with the iron-alum haematoxylin or any of the other methods of staining used. The lactophenol mount was more satisfactory than any previously made in Canada balsam. The only parts of the section that took the stain were the haustoria, the intercellular mycelium and the contents, and the host cell nuclei. The general stain, which affected the entire section when iron-alum haematoxylin was used, was eliminated. There was an added value too, in that the lactophenol made the walls of the cortical cells quite transparent so that even in thick sections the narrow portion of the mycelium penetrating the host cell and connecting the intercellular mycelium with the haustorium proper was easily viewed. Cotton blue proved a good general stain for the mycelium. Acid fuchsin showed up the nuclei of the mycelium well. Light green, on account of its brightness, transparency, and its equal staining capacity, was preferable to the other stains used. Starch grains, cytoplasm, and the walls of the mycelium showed up brightly and very slightly colored in the preparations. The great value of the method was in demonstrating so clearly the penetration of the wall of the host cell by the mycelium.

Description

The mycelium and haustoria described belong to the following species:

1. *Melampsora Abieti-Capraearum* Tubeuf.*
2. *Melampsorella Caryophyllacearum* Schroet.
3. *Pucciniastrum Epilobii* (Pers.) Otth.*
4. *Pucciniastrum Abieti-Chamaenerii* Kleb.*
5. *Calyptospora Goeppertiana* J. Kühn.*
6. *Hyalopsora Aspidiotus* (Pk.) P. Magn.*
7. *Milesia intermedia* Faull*
8. *Milesia marginalis* Faull & Watson*
9. *Milesia polypodophila* (H. P. Bell) Faull*
10. *Milesia Scolopendrii* (Fuckel) Arth.*
11. *Milesia Polypodii* White*
12. *Milesia vogesiaca* (Syd.) Faull*
13. *Milesia Kriegeriana* (Magn.) Arth.*
14. *Uredinopsis Atkinsonii* P. Magn.*
15. *Uredinopsis Phegopteridis* Arth.*
16. *Uredinopsis Osmundae* Magn.*
17. *Uredinopsis mirabilis* (Peck) Magnus*
18. *Uredinopsis Struthiopteridis* Störmer*
19. *Uredinopsis macrosperma* (Cooke) Magn.*

All of the species listed above belong to the subfamily, the Pucciniastreae of the family Melampsoraceae. The first nine species named above and those from 14 to 18 have their aecial stage on *Abies balsamea* (L.) Mill. The material bearing the aecial stages of the remaining species is of other *Abies* species. The material of *Uredinopsis macrosperma* available to the writer was on leaves of *Abies grandis* Lindl.

The telial hosts are listed in an earlier paper by the author (8), and later in a study† of *Milesia* species.

The Mycelium

The mycelium described is only for that stage of the rust borne on *Abies*. The mycelium of the 19 species, as is characteristic for the Uredinales, is intercellular, septate, uninucleate, branched, and bears haustoria in the interior of the host cells. The hyphae show some variation in diameter for the different species, and even within the species there is variation in the diameter of the mycelium. This is especially marked in the species *Hyalopsora Aspidiotus* and in *Milesia polypodophila*. In the former, the

* *Species so marked are those in which haustoria have been described in the aecial host for the first time.*

† *Hunter, L. M. The life histories of Milesia Scolopendrii, M. Polypodii, M. vogesiaca, and M. Kriegeriana. J. Arnold Arboretum, 17 : 26-37. 1936.*

hyphae measure from 3.4μ to 6.5μ, and in the latter, when found in the leaves, from 3μ to 4.5μ in diameter. The measurements taken for the mycelium of *Pucciniastrum Epilobii* and *P. Abieti-Chamaenerii* are the same, showing a narrow range in diameter from 2.5μ to 3.3μ. The mycelium of *Melampsorella Caryophyllacearum* occurring in the leaves shows the same range in diameter as that of the two *Pucciniastrum* species. The mycelium of *Melampsora Abieti-Capraearum* may be from 2.5μ to 4μ in width. The hyphae of all the *Uredinopsis* species that occur in the Timagami Forest Reserve, and of *Uredinopsis macrosperma* from the Western States, show the same variation, namely, from 2.5μ to 4μ in diameter. More often the hyphae of all of the *Uredinopsis* species measure approximately 3.3μ in width. The mycelium of *Milesia marginalis* measures from 2.3μ to 3.5μ, but more often it is 2.5μ in diameter. The mycelium of *Milesia Kriegeriana* measures approximately the same. The hyphae of *Calyptospora Goeppertiana* are noticeably more delicate or finer in appearance than any of the other species here considered. The measurements given for the diameter of the mycelium of this species are from 2μ to 3μ. All measurements of the mycelium of the species given above were made from hyphae that had developed freely within the air spaces of the mesophyll of the leaves.

The mycelium of *Melampsorella Caryophyllacearum* Schroet. has been described by DeBary (1) as systemic in the stem of *Abies pectinata* and causing broom formation. The mycelium of *Milesia polypodophila*, according to Faull (6), is systemic in the stem of *Abies balsamea* and causes loose broom formation. *Melampsorella Caryophyllacearum* and *Milesia polypodophila* alone, of all the species investigated by the writer, have systemic mycelium in the stem of the aecial host. The writer figures a drawing (Fig. 33) showing the mycelium of *Milesia polypodophila* as found in the intercellular spaces of the cortical tissue of infected *Abies*. The mycelium has a tendency to coil and to bear short rounded branches or knobs as well as ordinary branches. The diameter of the mycelium in the stem is from 4.5μ to 6μ in diameter, showing a higher average of width than the mycelium in the leaf. The wall of the mycelium in the leaf is less than 1μ thick, while that of the mycelium in the stem is 1.3μ thick. The age of the mycelium, in the stem examined, is at least two years. The mycelium in the leaf examined is likely not to be more than one year old, and new branches are perhaps much younger. It is interesting in this connection to recall that Sappin-Trouffy (20) found that the annual filaments in *Gymnosporangium clavariaeforme* Jacq. differed in diameter and in width of wall from the mycelium, which persisted from one year to another. The latter was found to have greater diameter and thicker walls than the former.

A table of measurements for the diameter of the mycelium of each species is given below:

Species	Diameter of mycelium in μ	
	In leaves	In stem
1. *Melampsora Abieti-Capraearum*	2.5 – 4	
2. *Melampsorella Caryophyllacearum**	2.5 – 3.3	
3. *Pucciniastrum Epilobii*	2.5 – 3.3	
4. *Pucciniastrum Abieti-Chamaenerii*	2.5 – 3.3	
5. *Calyptospora Goeppertiana*	2 – 3	
6. *Hyalopsora Aspidiotus*	3.4 – 6.5	
7. *Milesia intermedia*	2.3 – 3.5	
8. *Milesia marginalis*	2.3 – 3.5	
9. *Milesia polypodophila*	3 – 4.5	4.5 – 6
10. *Milesia Scolopendrii*	3 – 4.5	
11. *Milesia Polypodii*	3	
12. *Milesia vogesiaca*	3 – 3.7	
13. *Milesia Kriegeriana*	2.3 – 3	
14. *Uredinopsis Atkinsonii*	2.5 – 4	
15. *Uredinopsis Phegopteridis*	2.5 – 4	
16. *Uredinopsis Osmundae*	2.5 – 4	
17. *Uredinopsis mirabilis*	2.5 – 4	
18. *Uredinopsis Struthiopteridis*	2.5 – 4	
19. *Uredinopsis macrosperma*	2.5 – 4	

* *DeBary (1) described the systemic mycelium of Melampsorella Caryophyllacearum in the stem of Abies pectinata.*

The above table presents concisely the fact that for 17 of the species named, the diameter of the mycelium is within close range, and in many of the species the same variation is shown. Sappin-Trouffy (20) in connection with a discussion of the mycelium of the Uredinales investigated, stated that, apart from one exception, *G. clavariaeforme*, their diameter is sensibly uniform for the same species, but that it can be subject to slight modifications due to pressing in between the tissues. The writer finds modifications or variation in the diameter when the mycelium grows freely in the air spaces of the leaf or stem, as the case may be, of the host.

The Haustoria

Haustoria are described for the species listed above. Three types of haustoria—(1) hyphal, (2) helicoid, and (3) botryose, were found. The haustorium is frequently characteristic for the species. Some variation in type within the species was found, but in no case was it so great as that described by Sappin-Trouffy (19) for *Uromyces Betae* Pers. In every case the haustorium is greatly constricted at the point where it passes through the wall into the interior of the host cell. Invagination of the protoplasmic membrane seems to be the type of invasion. All the haustoria examined are uninucleate. No instances could be positively ascertained where more than one nucleus occurred in the usual nonseptate haustorium. In connection with the nucleus of the haustorium of *Milesia marginalis*, very occasionally, the writer found some extrachromatin material lying in the cytoplasm nearby the haustorial nucleus. In a few cases sheaths were found to be present around the haustoria. This was true for a few species only. Moss (16)

found sheaths or partial sheaths around the haustoria in the telial hosts of the following species—*Hyalopsora Aspidiotus*, *Milesia marginalis*, *Milesia polypodophila*, and *Uredinopsis Osmundae*. He also found branching a much more common feature of the haustoria in the telial hosts than the writer finds in the haustoria in the aecial hosts. A number of species under consideration have haustoria that bear a close relation to the host nuclei. Host nuclei are often indented by branches of the haustoria. Host cells invaded by haustoria are frequently filled with vacuolate cytoplasm, a condition that is common in the healthy leaves of *Abies balsamea*. Chloroplasts and starch grains are frequently met with in the invaded cells as in those free from the rust. Perhaps these conditions are to be expected since the *Abies*' hosts are all highly susceptible to the rusts borne on them, and a symbiotic relation (which exists in the early condition of the infection) causes less disturbance in the host than would happen if the hosts showed resistance to infection. In most of the material examined, the rust is comparatively young. Much of the material bears spermogonia in incipient stages, or mature spermogonia showing aecia in incipient stages. Even when leaves bearing mature aecia were examined for haustoria, sheaths, as a rule, were not commonly found. Ward (22) states: "In all cases where haustoria are developed, the mycelium enters into a peculiar symbiotic connection with the cells and for some time taxes them, as it were, rather than injures them directly". Rice (18) in the discussion of the haustoria of certain Uredinales concludes that they do little damage to the host except at the time of spore production. In connection with *P. Sorghi*, Mains (15) states that no harmful effect is shown by the host until after some period of time.

A description of the type of haustorium peculiar to each of the species studied follows:

Melampsora Abieti-Capraearum (Figs. 1 to 6)

The haustoria of *M. Abieti-Capraearum* are hyphal, simple or branched freely. They are uninucleate and are very frequently found in close association with the host nucleus, sometimes making a curve almost completely around it. Fig. 2 shows a haustorium that is septate. This is one of only two instances of septation found in the haustorium of any of the species investigated by the writer. Fig. 3 shows a young haustorium that is hyphal, very regular in outline, and surrounded by the cytoplasm of the host cell. The smaller, lower cell in Fig. 2 shows the narrow passage of the haustorium through the host cell wall. The mycelium just outside of the cell wall shows some indication of swelling but cannot properly be called an appressorium. Fig. 6 shows a much branched haustorium with one of the branches coming off from the side of the main branch. The haustoria are the same width as the intercellular mycelium or slightly dilated. Two or three haustoria may be present in a host cell, but it is more usual to find only one. The haustoria of this species occur frequently and are found in the mesophyll and in the epidermal cells of the leaf. Sheaths are sometimes present around the haustoria. None are figured here. As well as on *Abies balsamea*, haustoria

were found in dried herbarium specimens of *M. Abieti-Capraearum* on *Abies pectinata* D.C. Haustoria of a well developed hyphal type occur in the mesophyll cells of the leaf. Mature haustoria appear to be sheathed. No branching of haustoria was observed.

Melampsorella Caryophyllacearum (Figs. 7 to 14)

The botryose haustoria of *Melampsorella Caryophyllacearum* (*M. Cerastii* (Pers.) Schroet.) (1) were described first by DeBary (1) for the aecidial host. Pady (17) reports that on *Abies lasiocarpa* the haustoria differ in shape and size with a knoblike or irregular swelling at the tip from which numerous short fingerlike projections extend. Haustoria of a very complicated nature were reported by Magnus (11) on the mycelium of the uredinial host. Moss (16) described and figured botryose haustoria in the telial host. Schroeter (21) had already, in 1874, described the mycelium of the rust in the uredinial stage but was unable to locate haustoria. The writer has been able to find a number of stages in the development of the haustoria in the leaves of young diseased buds of *Abies balsamea*. Fig. 7 shows a branch pressing the cell wall inward. This is similar to DeBary's (1) findings for the same species in *Abies pectinata*. The figures from 7 to 13 represent a progressive development in the growth of the haustorium. The young haustoria are hyphal-like and slightly irregular, but very soon show indications of swelling and lobing. The mature haustorium is dilated and very much lobed (Fig. 14) in appearance. Fig. 12 shows a lobed haustorium attached to an appressorium by means of a very narrow passageway through the wall of the host cell. The haustorium in the outer cell at the right in Fig. 8 shows a connection with a slight appressorium. Figs. 7, 9, and 10 show either very slight or no appressoria. The haustoria are uninucleate and are frequently found pressing tightly against the host nuclei (Figs. 8, 11, 13, and 14). In all cases the haustoria are surrounded by the cytoplasm of the host cell. Chloroplasts are shown to be present in some of the cells (Fig. 8). Small starch grains are fairly abundant (Figs. 10 to 12). The haustoria occur abundantly in the mesophyll and in the epidermal cells, and occasionally even invade the vascular bundle. A mature haustorium in the spongy mesophyll of the leaf is found to be uninucleate and four-lobed. With a very high magnification the lobes appear to be indented giving a botryose appearance. In the vascular tissue of the leaf within a large woody cell two small uninucleate curved haustoria occur. This woody cell is in the transfusion tissue within the epidermis. It is frequently observed in longitudinal sections of the leaf that the mycelium runs for long distances in close association with the phloem.

Pucciniastrum Epilobii (Fig. 15)

The haustorium of *P. Epilobii* may be simple, hyphal, fairly straight, or curved. Frequently it is bulbous for about one-third of its length immediately after entering the host cell, as shown in Fig. 15. Occasionally the haustorium is branched. It is surrounded by the cytoplasm of the host cell. The connection between the haustorium and the intercellular mycelium is

shown in Fig. 15. No appressorium is shown here although appressoria are commonly found. The haustorium is only occasionally in contact with the nucleus of the host cell. Starch grains and chloroplasts appear normally in the cells where haustoria are found. No entire sheaths were located in sections of leaves that bore pycnia only, but occasionally small red staining areas (where safranin was used) were found lying close to the wall of the haustorium indicating the beginning of sheath formation. In the writer's opinion the haustoria of this species occur less frequently than in any of the other rusts on *Abies balsamea*. Nevertheless they have a greater variety of location and may be found in the epidermal cells, in the mesophyll cells, in the larger cells of the resin canals, and in the thin-walled cells of the pericycle of the leaf. Leaves that bore very mature aecia were examined for haustoria. It is interesting to note that complete sheathing of the haustoria was more commonly found in this material. When the haustorium was completely sheathed the cytoplasm of the host cell was greatly reduced. The writer's findings for this species would seem to be in agreement with Colley's (3) suggestion that, as in *Cronartium ribicola*, the development of the sheath seems to come with maturity. Moss (16) described allantoid or irregularly cylindrical haustoria for the mycelium of the uredinial stage of *P. pustulatum* (Pers.) Diet., and also for *P. americanum* (Farl.) Arth. He found that the haustoria are frequently in contact with the host nuclei and that sheaths are commonly developed around the haustoria.

Pucciniastrum Abieti-Chamaenerii

The form of the haustorium of *P. Abieti-Chamaenerii* is in general the same as that of *P. Epilobii*, excepting that the writer does not find branching in the former. No indications of sheathing were found in the haustoria of this species but the material examined was young and no leaves bearing aecia were investigated. The haustoria as in *P. Epilobii* are rarer than for the other species of rusts on *Abies balsamea* and they also have the same range of distribution in the host cells as is found in *P. Epilobii*.

Calyptospora Goeppertiana (Figs. 16 to 18)

The haustorium of *C. Goeppertiana* is hyphal-like. It is of the same width or slightly wider than the intercellular mycelium and is frequently irregular in outline. No appressoria of any appreciable size were observed. The mycelium is much constricted in its passageway through the wall of the host cell, but immediately after entering the host cell the haustorium becomes very slightly bulbous (Figs. 16, 17). Fig. 18 is not a median section through the haustorium. The haustoria are frequently found in close association with the nuclei of the host cells (Figs. 16, 18). The haustoria are uninucleate and are surrounded by cytoplasm. The haustoria occur quite abundantly in the mesophyll tissue of the leaf. Hartig (7) illustrates saclike haustoria of this rust in *Vaccinium*. The writer, too, has observed short, stout haustoria in *Vaccinium* and finds that those in the *Abies* host are slender, hyphal, and longer than those in the telial host.

Hyalopsora Aspidiotus (Figs. 19 to 21)

The haustorium of this species is hyphal in nature. It is frequently curved or sharply bent (Fig. 21), but may lie within the host cell as a straight clavate organ. Branching of the haustorium occurs sometimes. When it does occur it is never profuse. An appressorium is formed on the intercellular mycelium, previous to the entrance of the haustorium into the host cell. There is a marked constriction of the mycelium at the point of entrance. The mature haustorium is slightly dilated so that it is of somewhat greater diameter than the intercellular mycelium (Fig. 19). The haustorium is uninucleate. The haustoria are quite distinctive on account of their size. They are found occasionally encircling the host nucleus (Fig. 20) and sometimes indent it. Fig. 20 shows a haustorium in a cell in which chloroplasts occur normally. Starch grains and chloroplasts usually occur normally in all the cells of the mesophyll tissue in which haustoria are found. Fig. 19 represents an invaded cell showing only cytoplasm as appearing in that particular section. The haustoria are very abundant. They are found in the cells of the epidermis and in the mesophyll tissue of the leaves. Magnus (9) reported haustoria for *Hyalopsora Polypodii* in its telial host in 1892. In 1895 Magnus (10) stated that haustoria were not borne on the intercellular mycelium of *H. Aspidiotus*. Moss (16), in 1926, announced the occurrence of haustoria for this species in the telial host and described them as clavate or allantoid in shape and occasionally slightly lobed. He also found that sheaths were rarely present around the haustoria. The writer reports the finding of haustoria of *Hyalopsora Polypodii-Dryopteridis* in the aecial host, *Abies pectinata*, of European material obtained from Dr. Eugène Mayor. The haustoria resemble those of *H. Aspidiotus* and are of the clavate type. No sheathing of haustoria was found in either species.

Milesia intermedia (Figs. 22, 23)

The haustorium of *M. intermedia* is slender and hyphal-like, regular or irregular in outline, unbranched or occasionally showing a tendency to branch (Figs. 22, 23). The haustorium may be curved at the distal end. The mycelium immediately outside the constricted passage of the haustorium into the host cell is slightly swollen in the form of an appressorium (Fig. 22). The uninucleate haustorium (Fig. 22) is somewhat dilated and is in close association with the host nucleus. This contact is of fairly frequent occurrence. The cytoplasm of the host cell appears normal and chloroplasts occur. The cell at the left in Fig. 23 shows a young haustorium of clavate form. In both cells in this figure the cytoplasm is slightly drawn away from the wall of the host cell. The haustoria are abundant in occurrence. They are found in the cells of the epidermis, in the mesophyll tissue, and in the thin-walled cells of the pericycle. The mycelium separates the cells of the endodermis and invades the cells of the pericycle lying immediately within. Magnus (12) was unable to find haustoria for *M. Kriegeriana* in the telial host. He (13) also found no haustoria for *M. Feurichii*, but he did find short knoblike

swellings in the intercellular mycelium. Haustoria have not hitherto been reported for either the aecial or telial stage of *Milesia intermedia*.

Milesia marginalis (Figs. 24 to 26)

The haustorium of this species is slender and hyphal in character. The form may vary from slender, fairly straight hyphal haustoria to twisted, lobed, or branched haustoria. The haustoria are often curved at the tip. They are uninucleate. One case of septation of the haustorium was observed, as in *Melampsora Abieti-Capraearum*. In each cell of this unusual haustorium of *Milesia marginalis* a nucleus was observed. Septation occurred at about one-quarter of the length of the haustorium from its distal end. Fig. 26 shows the constricted passage of a haustorium through the host cell wall. No appressoria are shown in the figures but they normally occur. Starch grains and chloroplasts are found in the invaded cells, which are frequently occupied by vacuolate cytoplasm. Both cells of Fig. 25 show digestive areas around the haustoria. The dark line around the clear space surrounding the haustorium does not represent a sheath, but is merely the writer's method of calling attention to the digestive vacuole. Fig. 24 shows the beginning of a digestive vacuole. Sheathing of the haustorium in *M. marginalis* was found in only one instance. The haustoria are abundant. They are found in the cells of the epidermis, in the mesophyll tissue, and in the thin-walled cells of the pericycle, lying immediately within the endodermis. The haustoria may occur in close association with the host nucleus (Fig. 24), but more frequently they are found lying in the cell quite free from it (Figs. 25, 26). Occasionally the host nucleus is found indented by an arm of the haustorium (Fig. 24). Moss (16), in 1926, described the haustoria for the telial host. He (16) figures them as much branched organs of stouter nature than those represented by the writer as occurring on the aecial host of *M. marginalis*. He also observed sheaths of cuplike thickenings at the constricted bases of the haustoria.

Milesia polypodophila (Figs. 27 to 37)

The mycelium of this interesting species is systemic in the stem of the aecial host. According to Bell (2) and Faull (6) loose brooms are formed in the infected areas. The material used for examination was pieces of infected stem of *Abies balsamea* with attached leaves. Haustoria were found in both leaf and stem. They occur in the mesophyll cells of the leaf and in the cells of the cortex of the stem. The mature haustorium is spiral or helicoid in nature. Sometimes it is a true spiral and in the stem it may have as many as seven coils (Fig. 35). Quite frequently it is more loosely arranged and has four or five coils (Fig. 36). The haustoria found in the stem, almost without exception, were of the large coiled type (Figs. 34 to 37). The haustoria in the leaf are of the spiral type too. Figs. 27 to 32 are all of cells from a young invaded leaf. Fig. 28 shows a part of a haustorium that has at least three coils. All the haustoria are uninucleate and are frequently found in close association with the host nuclei. The haustoria in the leaf (Figs. 27 to 32)

have not as heavy walls as those found in the stem (Figs. 34 to 37). Fig. 29 shows a young haustorium in which the distal end is beginning to curve. Fig. 30 shows one somewhat more advanced developing a loose coil. Fig. 31 shows a haustorium that has developed a closer spiral. In Figs. 30 and 31 are shown the constricted passages of the mycelium through the cell wall, the slightly enlarged mycelium forming appressoria, and the coiled nature of the mycelium in the intercellular leaf spaces. In Fig. 27 the cells at the left abut on the stem. The mycelium is also closely projected against the stem. More intercellular mycelium is found closely applied to a nearby cell (Fig. 28). Fig. 29 represents a cell a little farther up the leaf, away from the stem, and Fig. 31 one still farther on, indicating the more or less complete invasion of the leaf by the parasite. The cytoplasm, chloroplasts, and starch grains appear to be normal in the invaded cells. Fig. 36 shows a haustorium in a cell of the cortex of the stem. Except for the presence of the invading organ, the cell is normal in appearance. Starch grains lie in the cytoplasm and the haustorium, which is in contact with the host nucleus, frequently borders on the large vacuole (Fig. 36). The writer was unable to trace the cytoplasmic layer all the way around the haustoria (Figs. 34, 36), but the cell contents appear so normal that it is likely that a very thin cytoplasmic membrane does persist around the haustoria. Fig. 37 shows a cell of the cortex in which the host cytoplasm seems to be breaking down. The host nucleus is not in contact with the haustorium. The nucleus of the haustorium itself shows a nucleolus, and appears to be in the resting stage. Figs. 34 to 36 show appressoria. Sheaths were not found to be present around the haustoria. The haustoria of *M. polypodophila* are numerous. As many as four have been found in a cell of the stem. Moss (16) describes a much branched haustorium for this species in its telial host. From his figures it is concluded that the haustorium in the telial host is very different in form from that in the aecial host. Dodge (4) calls attention to the different types of haustoria of *Gymnosporangium clavipes* Cke. & Pk. In the aecial host the haustorium is hyphal, long, irregular, and coiling, while in the telial host it is regular in outline and trim. Evans (5) also states that the haustoria of certain *Puccinia* species are very distinctive.

Milesia Scolopendrii (Fig. 41)

Haustoria of *M. Scolopendrii* occur on *Abies alba* Mill. and also on *A. concolor* Lindl. & Gord. in the mesophyll and epidermal cells of the infected leaves. The haustoria frequently have a slightly suggestive spiral (Fig. 41), or a very loose spiral form or, on the other hand, they may be merely hyphal. They are found in contact with the host nucleus (Fig. 41) or lying in the cytoplasm free from it. They are uninucleate, with vacuolate cytoplasm. They are more commonly not branched but may be branched dichotomously. Occasionally haustoria are observed with small knobs that may be the beginning of branches. The haustorium is connected to the intercellular mycelium by a very narrowly constricted passage through the cell wall. There is evidence that the leaf tissue of *A. concolor* is much more adversely

affected by the rust invasion than that of *A. alba*. The haustoria in epidermal cells are shorter than those in the mesophyll cells. They are hyphal, usually inflated at the base, and narrowed toward the tip or distal end.

Milesia Polypodii (Figs. 42 to 43)

Haustoria of *M. Polypodii* are found in mesophyll and epidermal cells of leaves of *Abies concolor* and *A. alba* infected with the rust (O, I). The haustoria are hyphal (Fig. 42) but often irregular or branched dichotomously or branched much more freely (Fig. 43). A lesser lobed or knobbed effect is often observed. The distal end of the haustorium is frequently found in contact with the host nucleus. As many as three branches have been found indenting the nucleus. The haustorium itself is uninucleate and has vacuolate cytoplasm. In a section from which Fig. 43 was drawn, while observed under oil immersion, the proximal end of the haustorium could be viewed connected by a narrowly constricted passage through the cell wall and a somewhat inflated appressorium beneath it. The haustoria of *M. Polypodii* are characteristic and serve as an aid in identification of the species. The host cells of *Abies concolor* are often to some extent affected adversely in comparison with those of *Abies alba* infected with *Milesia Scolopendrii*. Figs. 42 and 43 represent cells that, apart from the invasion by haustoria, appear to be normal.

Milesia vogesiaca (Fig. 44)

Haustoria occur in the mesophyll and epidermal cells of infected leaves of *Abies alba*. They are uninucleate, containing vacuolate cytoplasm, and are mainly hyphal in nature. Occasionally some are found that have a suggestion of a very loose spiral form. Branching is rare. The distal end of the haustorium is frequently in contact with the host nucleus (Fig. 44). Haustoria are embedded in the cytoplasm of the host cell. In the epidermal cells the haustoria are hyphal but a few were found with somewhat inflated tips. The haustoria enter the cell through a constricted passage in the wall. When the rust is more mature there is evidence of sheathing of the haustorium.

Milesia Kriegeriana (Fig. 45)

Haustoria of *M. Kriegeriana* occur in the epidermal and mesophyll cells of the infected leaves of *Abies alba*. The haustoria are uninucleate with vacuolate cytoplasm and hyphal in form (Fig. 45) lying in the cytoplasm of the host cell. Frequently the tip of the haustorium is in contact with the host nucleus. The haustoria of the epidermal cells are shorter than those of the mesophyll cells. They are hyphal and inflated slightly at the basal end. The haustoria of this species resemble those of *Milesia intermedia* on *Abies balsamea*, and are more distinct or characteristically one type than are the haustoria of *M. Scolopendrii* or *M. Polypodii*.

Uredinopsis Atkinsonii (Figs. 38 to 40)

The haustorium of *U. Atkinsonii* is typically hyphal in character and unbranched. It is slightly wider in diameter than the intercellular mycelium

and is uninucleate. The wall of the haustorium is irregular. The appressorium is very slight. Chloroplasts and starch grains are found in the cells invaded by the parasite (Figs. 39, 40). The protoplasm is pushed in by the mycelium as it grows. Colley (3) is certain that the haustoria of *Cronartium ribicola* Fischer do not pierce the plasma membrane of the host. Figs. 38 and 40 show the narrow passage through the host cell wall by which means the very much constricted mycelium enters the host cell. The writer occasionally observed a haustorium lying closely alongside the host nucleus, but not indenting or deforming it. The haustoria examined were from leaves that bore mature or incipient stages of spermogonia. The haustoria are fairly abundant. They occur in the leaf in the epidermal cells, and in both the thin and heavy walled cells of the pericycle, though rarely in the latter. The intercellular mycelium separates the cells of the endodermis and passes in between them towards the pericycle. As noted previously Magnus (9), in 1892 and again (14) in 1904, has stated that there are no haustoria in the genus *Uredinopsis*. Moss (16), in 1926, described lobed and branched haustoria, in the telial hosts, for three *Uredinopsis* species, namely, *U. Atkinsonii*, *U. Osmundae*, and *U. Phegopteridis*. Moss (16) figures haustoria for *U. Atkinsonii* and *U. Osmundae*. These figures show much stouter haustoria than the writer finds on the mycelium of *U. Atkinsonii* in the aecial host. Also branching of the haustorium was not found by the writer in the aecial host. Moss (16) described sheaths for the mature haustoria in the telial hosts. The writer finds no sheaths in the material examined for the haustoria in the aecial host.

Uredinopsis Species

Haustoria have been found by the writer in the *Uredinopsis* species on *Abies balsamea*, namely *U. Atkinsonii*, *U. Phegopteridis*, *U. Osmundae*, *U. mirabilis*, and *U. Struthiopteridis*. In each species they are hyphal in form and are very similar in type. Slight appressoria usually occur just outside of the host cell. From the appressorium a narrow tube penetrates the host cell wall. No sheathing of the haustoria was observed. Even in the dried herbarium material of *Uredinopsis macrosperma* remains of hyphal-like haustoria were observed in the epidermal and mesophyll cells of the leaf.

Conclusion

Further study of more mature aecial material of most of the species investigated should prove interesting. Such an investigation would finally determine whether the haustoria, at maturity of the rust, are frequently sheathed, and also to what extent, and perhaps in what way, the host cells are injured. Many of the rusts of *Abies* that develop pycnia or spermogonia and aecia on leaves of the current season cause blanching of the infected leaves and early defoliation. This is very true for *Abies balsamea* when infected with *Uredinopsis* species. According to Bell (2) the needles infected with *Milesia polypodophila* turn pale green, but are never blanched as those infected with

Uredinopsis species. Leaves bearing only spermogonia or both spermogonia and aecia of *M. polypodophila* or *Hyalopsora Aspidiotus* show stimulation by the parasite. The infected leaves appear somewhat enlarged even in the late pycnial stage. There is also a difference in the staining reaction of the host tissue as compared with the normal leaf of *Abies balsamea*.

This investigation, initiated at the University of Toronto, has been carried on at intervals since. The writer wishes to thank Dr. J. H. Faull of Harvard University for the abundance of excellent material offered for the investigation, and also Dr. Eugène Mayor, Switzerland. Thanks are extended to Dr. Faull for helpful criticism at intervals during the investigation.

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(Note: Figs. 1-45 will be found on pp. 235-238. All figures are camera lucida drawings made by the author.)

Explanation of Figures

FIGS. 1-6. *Haustoria of Melampsora Abieti-Capraearum in the mesophyll cells of the leaf of Abies balsamea.* ×518.

FIGS. 7-13. *Haustoria of Melampsorella Caryophyllacearum in young and developing stages in the cells of the mesophyll of the leaf of Abies balsamea.* ×518.

FIG. 14. *A mature haustorium of M. Caryophyllacearum in a cell of the mesophyll of the leaf of Abies balsamea.* ×464.

FIG. 15. *The haustorium of Pucciniastrum Epilobii in a cell in the mesophyll of the leaf of Abies balsamea.* ×643.

FIGS. 16-18. *Haustoria of Calyptospora Goeppertiana in the mesophyll cells of the leaf of Abies balsamea.* ×518.

FIGS. 19-21. *Haustoria of Hyalopsora Aspidiotus in the mesophyll cells of the leaf of Abies balsamea.* ×555.

FIGS. 22-23. *Haustoria of Milesia intermedia in the mesophyll cells of the leaf of Abies balsamea.* ×518.

FIGS. 24-26. *Haustoria of Milesia marginalis in the mesophyll cells of the leaf of Abies balsamea.* ×518.

FIGS. 27-32. *Haustoria of Milesia polypodophila in the mesophyll cells of the leaf of Abies balsamea.* ×560.

FIG. 33. *The intercellular mycelium of M. polypodophila in the cortex of the stem of Abies balsamea.* ×500.

FIGS. 34-37. *Haustoria of M. polypodophila in the cells of the cortex of the stem of Abies balsamea.* FIGS. 35 and 37, ×560; FIGS. 34 and 36, ×600.

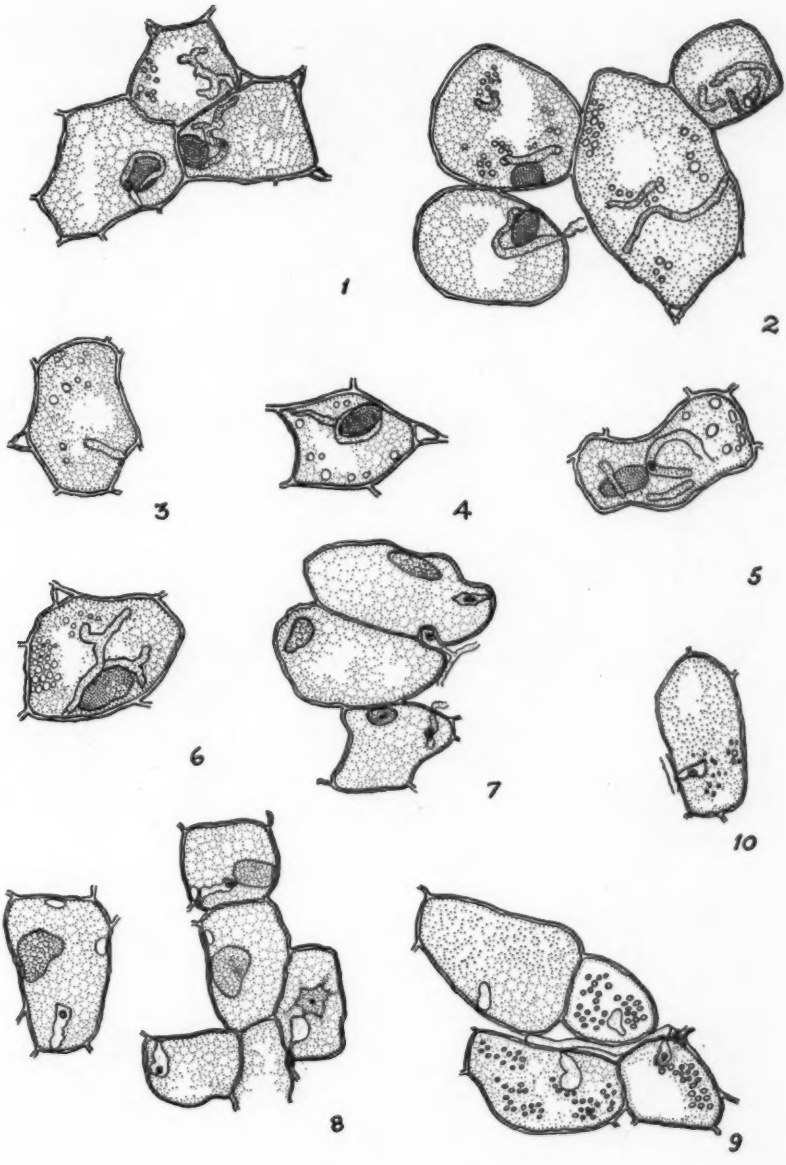
FIGS. 38-40. *Haustoria of Uredinopsis Atkinsonii in the mesophyll cells of the leaf of Abies balsamea.* ×518.

FIG. 41. *Haustorium of Milesia Scolopendrii in the mesophyll of the leaf of Abies alba.* ×740.

FIGS. 42-43. *Haustoria of Milesia Polypodii in the mesophyll of the leaf of Abies concolor.* ×740.

FIG. 44. *Haustorium of Milesia vogesiaca in the mesophyll of the leaf of Abies alba.* ×740.

FIG. 45. *Haustorium of Milesia Kriegeriana in the mesophyll of the leaf of Abies alba.* ×740.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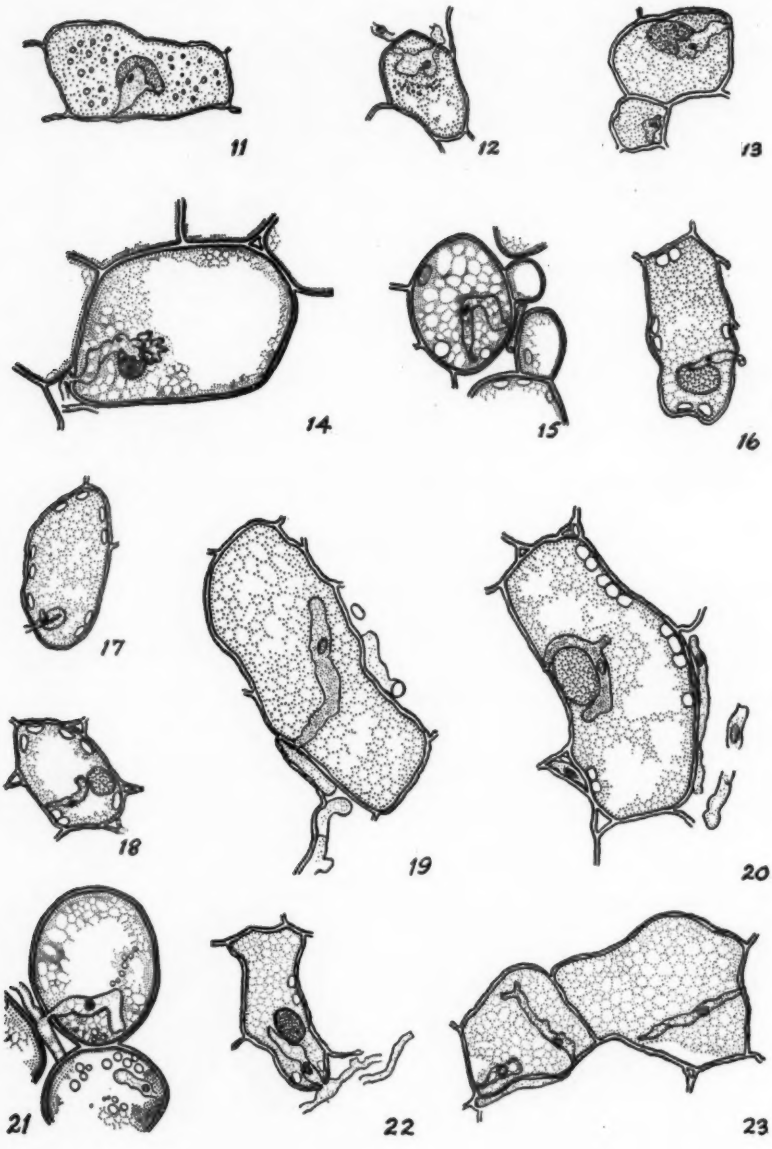
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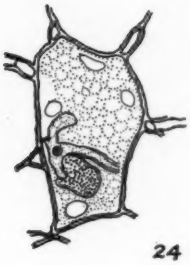

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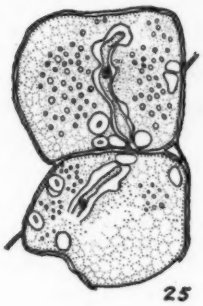

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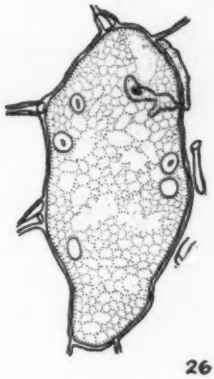

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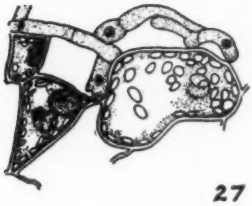

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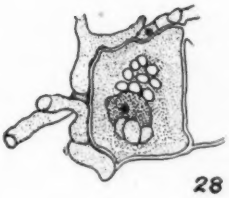

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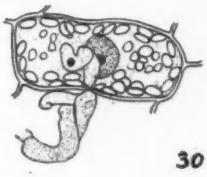

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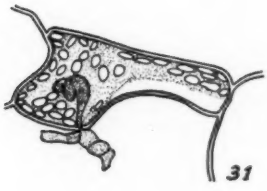

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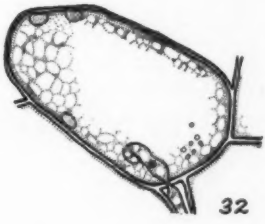

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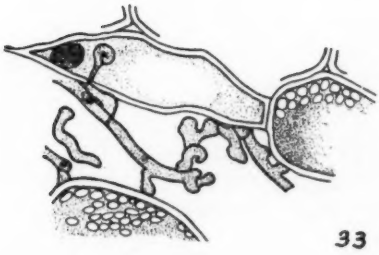

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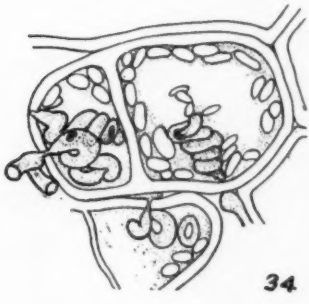

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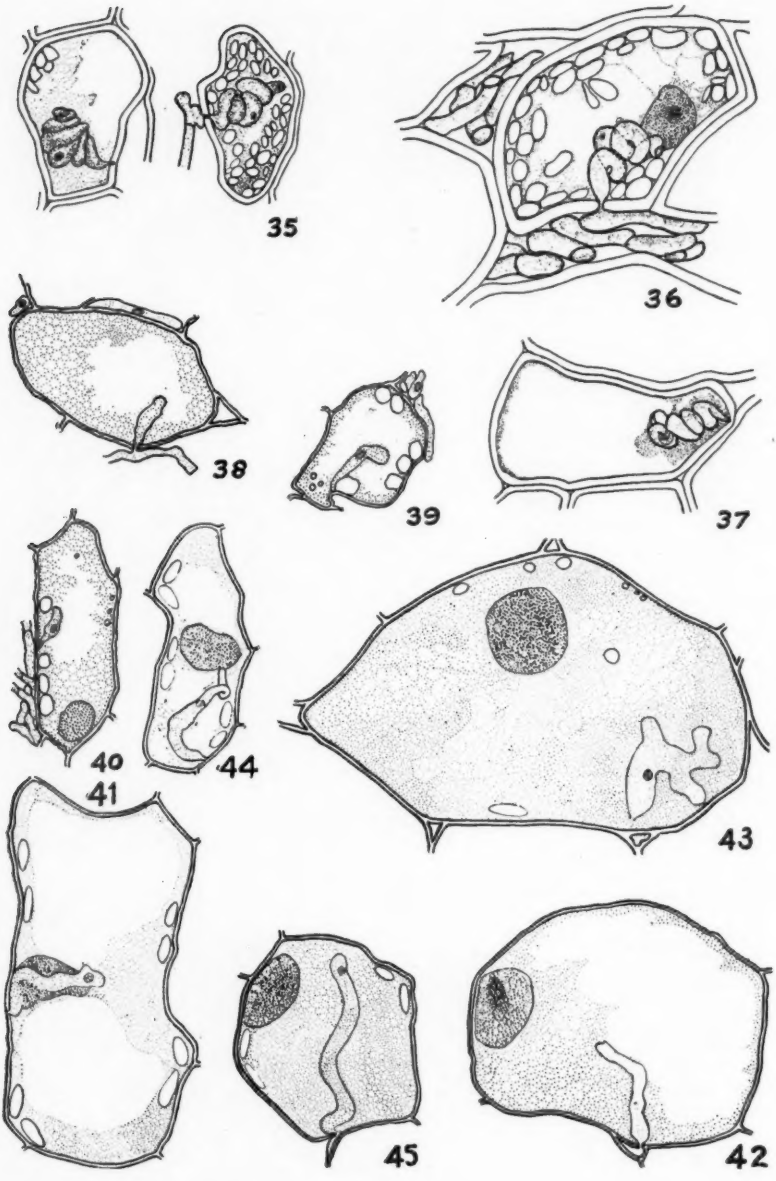
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TRANSLOCATION OF 2,4-D IN INJECTED FLOWERING PERENNIAL SOW THISTLE PLANTS[1]

By W. G. Corns[2]

Abstract

Visible response to injection of flower heads of perennial sow thistle plants with herbicidal concentrations of 2,4-D appeared only in the uppermost regions of the plants. The herbicide moved downward through peduncles supporting treated heads, then it moved upward through neighboring peduncles. Apparently this pronounced ascent of herbicide was associated with transport of plant solutions to regions of rapid development and transpiration.

On the other hand, response to injection of severed stems of flowering sow thistle plants was not limited to the region of treatment. The herbicide moved downward in treated stems, upward in their intact lateral branches, leaves, and flowers, and extensively downward and laterally in the root system.

Significance of this multidirectional movement is discussed.

Introduction

Translocation of chemical from the tops down through the extensive root system of perennial weeds is obviously of first importance in effecting their eradication or control by means of herbicides. It is relatively easy to kill the aerial growth of such plants but it is often extremely difficult to bring about adequate penetration of chemical into underground parts that are so effective as a means of reproduction. There is, therefore, a need for further studies, under natural conditions, of factors affecting the transport of herbicides in various plants.

The present paper reports a study of the movement and effects of the selective weed killer, 2,4-dichlorophenoxyacetic acid (or reaction product) following its application to flowers and to severed stems of perennial sow thistle plants (*Sonchus arvensis*) growing under field conditions in black loam soil at Edmonton.

Access to literature relating to natural and synthetic growth regulating substances is available in the publications of Boysen Jensen (3), van Overbeek (10), Thompson *et al.* (12), Thomson (13), Went (16), Zimmerman and Hitchcock (17), and others.

It is generally agreed that movement of growth regulators from leaves into other parts of plants is associated with the translocation of organic food material mainly in the phloem and parenchyma cells. Hitchcock and Zimmerman (5) and Ferri (4) showed that synthetic growth substances can move upward in plants from the soil or from application in lanolin around the stem. Hitchcock and Zimmerman (6) also report that applied growth substances such as indoleacetic and indolebutyric acids apparently move up and down in

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plant tissues. Beal (2) demonstrated downward movement of 4-chlorophenoxyacetic acid to roots from treated stems of sweet pea plants. Weaver and DeRose (15) in their studies of translocation of 2,4-D in young bean plants also obtained evidence to support the theory of upward movement of growth regulators in the xylem and downward movement mainly in the phloem. Mitchell and Brown (7) working with bean plants observed that 2,4-D applied to leaves having a low sugar content, or to young rapidly growing leaves, produced little or no visible response in other parts of the plants. Under conditions favorable to translocation of organic food materials, the reactant moved into the stems but apparently did not move upward through the petioles of opposite leaves. Thus, as one might expect, the extent and direction of transport of 2,4-D or its reaction products are shown not to be completely independent of other translocation processes within the plant.

Published reports of basic studies of translocation of 2,4-D in deep rooted perennial weeds are relatively few in number. Tukey and Hamner and their associates have described histological changes in sow thistle and bindweed (14), and biochemical changes in the latter (11), following application of 2,4-D. They found definite similarities in the general mobilization of carbohydrates and nitrogen of bindweed as compared with the effect of other growth regulators on bean seedlings (11). This provides some indication that results with annual plants may have general application in connection with effects of translocation of 2,4-D.

Apparently the application of 2,4-D specifically to flowers and peduncles of plants such as tomato and cucumber has usually been done with concentrations less than 100 p.p.m. in experiments designed to study production of seedless fruits (17). It has already been noted that in the present work herbicidal concentrations of 2,4-D were applied to flowers and cut stems of perennial sow thistle. The work of Arny (1) shows that readily available carbohydrates in roots of sow thistle plants are least at flowering time. Hence we might expect that treatment at this stage of growth would be timely for purposes of weed control. Field practice seems to support this view (9).

Experimental

1. Injection of Flower Heads of Perennial Sow Thistle

Experiment I

Materials and Methods

Preliminary tests were performed on sow thistle plants growing in a heavily infested garden. Rows of plants approximately three feet apart were used after hoeing out the unwanted plants.

At the early flowering stage a single head on each plant was tagged for treatment (July 17). An 0.1 ml. aliquot of 2,4-D solution applied from a graduated 1 ml. hypodermic syringe was carefully delivered, without runoff, among the bases of the flowers making up an individual head. Rows of 15 plants each were treated as follows:

(1). Check—no treatment.

(2). Check—distilled water only.

(3). Triethanolamine formulation of 2,4-D (Naugatuck brand).

(4). Sodium salt of 2,4-D (J. T. Baker Co.).

(5). Morpholine salt of 2,4-D (Baker).

Each formulation was used to make 0.5, 1, and 2% solutions calculated as 2,4-D acid. A row of plants was treated with each solution, 0.1 ml. being applied as previously indicated to one flower head per plant. All the heads on each plant were then covered with a glassine bag to prevent seed dispersal. A week later bags were removed temporarily during observations of effects of treatment.

Results

Counts of total numbers of dead heads and dead peduncles on 10 plants per row appear in Table I.

TABLE I

TOTAL NUMBER OF AFFECTED PARTS ON 10 SOW THISTLE PLANTS ONE WEEK AFTER TREATMENT OF ONE FLOWER HEAD PER PLANT WITH 0.1 ML. 2,4-D SOLUTION

2,4-D formulation	Dead flower heads	Dead peduncles
Triethanolamine		
0.5%	10	5
1.0%	10	7
2.0%	19	19
Sodium		
0.5%	10	4
1.0%	16	13
2.0%	22	22
Morpholine		
0.5%	10	1
1.0%	13	13
2.0%	40	40
Checks		
Some flower heads were closed and dry with yellowing peduncles but none had blackened involucre or withered peduncle		

Flowers killed by 2,4-D were distinguished by their blackened brittle involucre from those closed and dry as a result of other causes. Dead peduncles were those visibly burned and withered by the chemical, which obviously moved downwards from the point of treatment and in many cases then moved up neighboring peduncles killing them and their flowers. This behavior is consistently borne out by the data, which show increased burning response to 2,4-D transport resulting from increasing concentration of chemical. Because of displacement of flower stalks caused by enclosure in bags, it was

not possible in this test to distinguish peduncles not killed but showing bending response attributable to the 2,4-D treatment.

Apparently as a result of the confinement of the flower heads within the bags used to prevent seed dispersal, virtually all flowers on treated and untreated plants became sterile. All flower heads treated with 2,4-D were killed but obviously it was impossible to reach any conclusions as to the possible effects of the chemical on yield and viability of seed of untreated flowers on treated plants. Unfortunately for purposes of comparison there was no unbagged material in the same experimental area. Examination of a bulked sample of seed collected from plants in other locations, however, indicated that under natural conditions at least 40 or 50% seed set can be expected.

Experiment II

Materials and Methods

Plants for this experiment and the one to be described in Expt. III (Injection of cut stems) were grown from pieces of root stock about $\frac{1}{4}$ in. in diameter and 2 in. long, transplanted in June with spacing three feet apart within and between rows. Aqueous solutions of morpholine salt of 2,4-D (Baker) were used in 1%, 2%, and 4% concentrations (as 2,4-D acid) and 0.1 ml. was applied per plant as in Expt. I. Treatments were randomized, a group of 15 plants receiving each concentration of solution on Aug. 6 (early flowering stage, plants about 26 in. tall). Water treated and untreated controls were included.

In this experiment inflorescences were not bagged until a week after treatment, hence it was also possible to note the number of peduncles noticeably bent or twisted, but not withered as a result of movement of herbicide.

Results

Evidence of penetration of growth regulator was visible within four or five hours from time of treatment. Peduncles of several treated flower heads became limp and darkened in color during this time. A summary of results appears in Fig. 1.

Comparison of results shown in Table I with those given in Fig. 1 indicates somewhat less injury per plant in Expt. II. This may be mainly attributable to the fact that inflorescences were not covered immediately after treatment of plants in the second test. For this reason temperature–humidity relations would be different, also the weather was somewhat warmer at the time of the first experiment. In any case, the significance of the results of both experiments is the same. The data show increased plant response to increased concentration of chemical. The 2,4-D or some reaction product moved both down and up in the plant tissues and, as far as could be ascertained visually, it remained confined to the extreme upper regions of the plants with no effect on lower stems and leaves or on roots. Plants were examined periodically for nine weeks until the end of the season.

Effect of Treatments on Seed Production

Again as in Expt. I, there was practically complete sterility of flower heads of treated and untreated plants. The bagging practice seems to have been responsible for the sterility but since the main observations on direction and localization of movement of chemical were made before the inflorescences were covered they were free from the influence of this complicating factor.

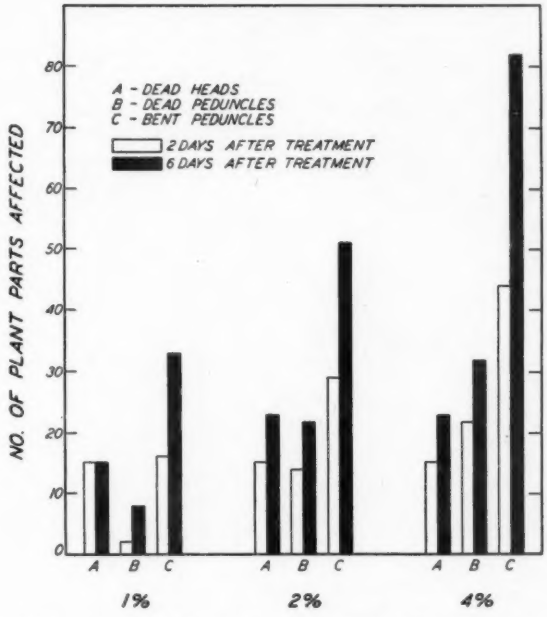


FIG. 1. *Total number of affected parts on 15 sow thistle plants two and six days after treatment of one flower head per plant with 0.1 ml. of solution of morpholine salt of 2,4-D (1%, 2%, and 4% solutions as 2,4-D acid equivalent).*

2. INJECTION OF CUT STEMS

Experiment III

Materials and Methods

Sow thistle plants of the same stock and plot location as those treated in Expt. II were used in a concurrent experiment to observe the effects, on remaining plant parts, of 2,4-D injected into the stump after cutting off the upper portions of the plant stem. The main stem was cut off about 8 to 10 in. above ground level and whenever branching pattern permitted, two lateral branches arising near the base of the stem were left complete with their developing flowers.

Aliquots of the 1%, 2%, and 4% solutions of morpholine salt used in the foregoing experiment were delivered by means of a graduated 1 ml.

hypodermic syringe into the central cavities of the respective stem stumps. A single 0.4 ml. aliquot was used for each plant, thus in this experiment stem injections of 0.4 ml. of 1% solution were equivalent in 2,4-D acid content to the flower injections of 0.1 ml. of 4% solution in Expt. II. Where pith obstructed the stem cavity it was first pierced by a wire probe. Each treatment, including untreated plants and controls treated with distilled water was replicated 15 times. Stems were sealed with scotch tape after treatment.

Results

Two days after treatment, browning of the exterior of the stem near place of application of 2,4-D was a common symptom of injury among the plants treated with the 2% and 4% concentrations. In general, plants were affected in proportion to concentration of 2,4-D applied.

There was naturally some variability among plants even though they were of the same age. Smaller somewhat more succulent lateral branches were affected most rapidly. They curled significantly indicating movement of reactant down the treated stump and up the branches to the developing flowers.

Curling of leaves and branches was followed by loss of chlorophyll and appearance of mottled red and yellowish coloration of leaves. This changed to brown, marking the death of affected aerial parts (See Figs. 2–8).

Some of the observations recorded over a period of nine weeks are summarized in Table II.

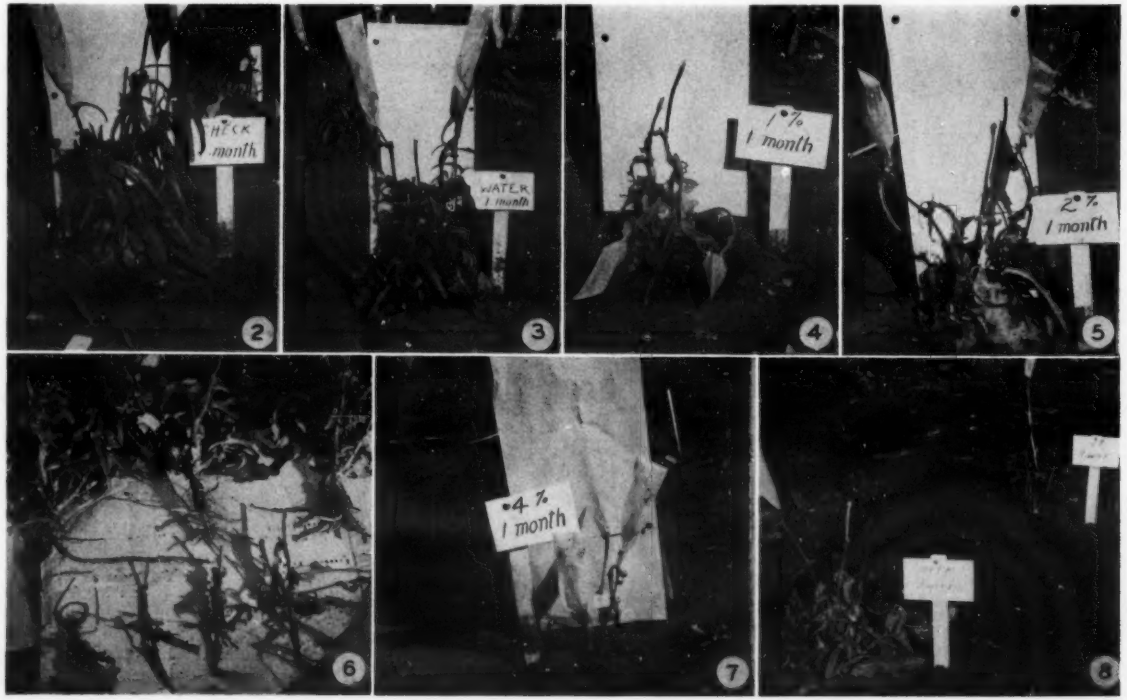
TABLE II

NUMBER OF SOW THISTLE PLANTS PER GROUP WITH ALL AERIAL PARTS DEAD FOLLOWING STEM INJECTION AT FLOWERING TIME WITH 2,4-D SOLUTION (15 PLANTS PER GROUP)

Treatment	Weeks after treatment			
	4	6	7	9
2,4-D solutions				
1%	6	6	6	12
2%	6	10	12	14
4%	9	11	13	14
Water	0	0	0	10 (dying)
Check	0	0	0	8 (dying)

Nine weeks after treatment (Aug. 6–Oct. 6) the untreated and water-treated controls were beginning to die from natural causes. As the data indicate, however, they were still in better condition than were the treated plants. In addition, a considerable amount of new growth had sprung up from pruned branches of the control plants. No such growth appeared on treated plants (See Pl. I).

As also noted in Expts. I and II, bagged flower heads left to mature on lateral branches of treated and control plants produced no seed.



Appearance of severed sow thistle plants after stem injection.

FIG. 2. *Check, one month from time of treatment.* FIG. 3. *Check: distilled water, one month from time of treatment.* FIG. 4. *1% 2,4-D solution, one month from time of treatment.* FIG. 5. *2% 2,4-D solution, one month from time of treatment.* FIG. 6. *Check plants (above) and comparable 2,4-D treated plants (below) six weeks after treatment.* FIG. 7. *4% 2,4-D solution, one month from time of treatment.* FIG. 8. *Check plant (foreground) and plant treated with 4% 2,4-D solution (background) nine weeks from time of treatment.*

Nine weeks after treatment part of the root system of five plants from each group was removed by digging to a depth of one foot in a cylinder of soil 33 in. in diameter having the plant stem as its central point. Care was taken to avoid, in so far as possible, breakage of roots from the parent plant, and to include all portions disconnected as a result of rotting of treated material. Although the technique was subject to error, the differences recorded in Table III are in line with visual observations of lessened vigor and substance of roots from treated plants (See Pl. I).

TABLE III

FRESH WEIGHT AND APPARENT CONDITION OF SOW THISTLE ROOTS IN TOP FOOT OF SOIL WITHIN A RADIUS OF 16½ IN. FROM PLANT STEM NINE WEEKS AFTER INJECTION OF CUT STEMS WITH 2,4-D SOLUTIONS

Treatment	Root wt., gm.				
	Check	Water	1% 2,4-D	2% 2,4-D	4% 2,4-D
Plants 1	11	50	24	17	0
2	33	22	19	10	8
3	34	18	31	6	9
4	26	18	8	5	8
5	37	37	31	4	3
Total	141	145	113	42	28
Mean	28	29	23	8	6
Estimated % dead roots	0	0	25	40	70
Estimated % extensively deteriorated roots	0	0	45	35	25

In addition to the dead material, several of the roots were severely damaged throughout their length in the volume of soil examined. As one would expect, damage decreased with distance from the plant. Affected roots were very thin, spongy, brown, and knobby. About one quarter of the extensively deteriorated roots, however, still possessed slightly enlarged resting buds but it seems likely that these were of greatly reduced vitality. Further observation and experiments are necessary to settle this point.

Discussion

Results, following injection of flower heads of perennial sow thistle plants with 2,4-D, show that there was a downward movement of herbicide through peduncles supporting the treated heads. It seems likely that opposition to such movement would be decreased as development of flower heads became arrested. On the other hand, the descent of chemical was apparently completely stopped whenever avenues for its upward movement in neighboring peduncles were reached. It seems that transport of reacting chemical was then governed by movement of sap to the young rapidly developing parts of the plant. This is clearly shown by the numbers of dead flowers and of dead

or twisted peduncles. Apparently movement of herbicide in the peduncles was not confined to any particular tissue region. Highest concentrations of chemical produced most response.

As far as could be ascertained visually, there was complete lack of response below the uppermost region of head-injected plants. Two months after treatment the appearance of the remainder of the aerial portion and of the entire roots was still indistinguishable from the controls.

The evidence for multidirectional transport is supported by the results of injection of sow thistle stem stumps. Movement down the stem resulted in death of a high proportion of roots. In addition, some of the chemical moved upwards in intact lateral branches, entered their leaves, produced characteristic symptoms of growth disturbance within 24 hr. from treatment, and caused damage as indicated in Tables II and III and Pl. I.

Because of differences in technique the experiments on flower injection are not strictly comparable with the test in which severed plants were used. Nevertheless, some comparisons appear to be admissible and instructive. In quantity of 2,4-D applied, the acid content of the amount of 4% solution used for flower treatment of one group of plants was equivalent to the acid content of the greater quantity of 1% solution used in stalk treatment of another group of plants. It has already been shown that the response to the latter treatment was appreciably greater than that resulting from injection of flower heads. In no case did death of a portion of a plant, anywhere nearly equivalent in mass to that killed by stalk treatment, occur after flower treatment. Admittedly there was better opportunity for immediate dispersal of 2,4-D inside the cut stems but it also seems logical to assume that as a result of cutting the stems the upward movement of liquids within the plant was reduced, thus permitting 2,4-D solution to move more extensively downwards. It has already been noted that upward movement occurred in intact lateral branches, leaves, and flower peduncles. According to the theories discussed in the introduction we would not expect appreciable upward movement through phloem of leaves functioning under favorable condition, as these were. It seems logical to assume, therefore, that ascent of herbicide into leaves occurred through their xylem.

Now if the behavior of entire and of severed flowering sow thistle plants following spraying or dusting of their leaves and stems with herbicide is found to be similar to that noted in the experiments described above, then an immediate practical application of the findings would suggest itself. Mowing of infested uncropped land at a time when sow thistle root reserves are lowest (1) could be done at a height to leave adequate leaf surface for spraying. Mowing would also help to control certain intermingled annual weeds such as red root pigweed, which is moderately resistant to 2,4-D.

We are not aware of any published comparative results of spraying at flowering stage of intact and mowed sow thistle plants. Trials of this nature are anticipated.

Summary and Conclusions

Injection of single new flower heads of perennial sow thistle plants with herbicidal concentrations of 2,4-D resulted in localized response to treatment. The stimulus moved down the peduncles of treated flower heads and up several neighbouring peduncles indicating that translocation of 2,4-D is associated with flow of liquid to active centers of development or of transpiration. Apparently movement of herbicide in peduncles was not confined to any particular tissue region. Severity of response varied directly with concentration of 2,4-D used.

Injection of severed stems of perennial sow thistle plants with 2,4-D resulted in extensive kill of intact lateral branches and leaves and of root growth. Multidirectional movement of selective herbicide is thus shown to occur. Apparently ascent of herbicide into leaves occurred through their xylem. It is suggested that abscission of stems and flowers results in a reduction of the normal upward movement of liquids thus permitting more extensive downward movement of herbicide, perhaps associated with translocation of nutrients to storage areas.

If the above results are applicable under practical conditions of application of selective herbicide, it would be advisable, prior to chemical treatment of flowering sow thistle plants growing on uncropped land, to mow them at height of several inches above ground.

Acknowledgment

Grateful acknowledgment is expressed to the National Research Council of Canada, who assisted the research with a grant.

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LETHAL EFFECT OF ABSORBED RADIOISOTOPES ON PLANTS[1]

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Abstract

The lethal dose of P^{32} and Sr^{90} for wheat, barley, and sunflower seeds is approximately 1.4 microcuries per seed (0.05 rd.). Radioautographs indicate that at five weeks' growth the distribution of phosphorus in a wheat plant is fairly uniform whereas that of strontium is very uneven, practically all the strontium being concentrated in the first two leaves.

Introduction

It is now well known that radiations can produce marked physiological effects in living cells. Consequently, it is important when conducting tracer experiments with biological material, to keep well below the biological threshold, for otherwise the conclusions drawn may be invalidated by occurrences due to the radiation itself. A good deal is already known concerning the action of X rays, γ rays, and β particles on living cells (4) but very little has been published concerning the action on plants of beta rays from radioactive tracers.

The present experiments were designed to measure the lethal dose of radiophosphorus, P^{32}, and radiostrontium, Sr^{90}, for germinating seeds of wheat species, barley, and sunflower. The experiments grew out of tracer studies in which P^{32} was used to measure the uptake of phosphate fertilizer by wheat plants (8).

Experimental

Method

Method of Counting

The activities of solutions were determined by evaporating down an aliquot on a platinum dish that was then slid under the window of an end-on Geiger Müller chamber, having a thin window of mica, and counted. The chamber was connected to a scale of 128 scaling circuit and any sample was counted for a sufficient length of time to give approximately 10,000 counts (standard deviation is then about 1%). By choosing a suitable aliquot the rate of counting was kept below 2000 counts per minute and the correction for resolving time of the tube (2×10^{-4} sec.) was then less than 1% (10).

Plant materials were wet ashed before counting and, where necessary, corrections were made for self-absorption by the active material (8). The

[1] *Manuscript received March 13, 1948.*

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natural rate of the counting tube (so-called 'background') was allowed for by subtracting it from the total counting rate for any sample. For P^{32}, half life 14.3 days, the radioactive decay was allowed for by taking an aliquot of the original stock solution, evaporating it to dryness, and counting it immediately before and after counting the unknown material. The aliquot of the original thus serves as a standard and eliminates the necessity of correcting for the decay of the P^{32} or for small fluctuations in the counter.

For Sr^{90} (half life 25 years (7)), counter fluctuations were allowed for by comparing the unknown with a uranium oxide standard.

Absolute Number of Disintegrations

In determining the lethal dose, absolute tracer activity is required. While methods are available for the measurement of absolute disintegration rates (3) a simpler procedure is to use a β-ray standard, preferably identical in energy distribution with those being measured. In the present experiments, the factor converting recorded counts to absolute number of disintegrations was determined using a radium D + E standard obtained from the Bureau of Standards, Washington. The counting efficiency of the counter for the radium D + E standard was first determined and then the disintegration rate of the P^{32} standard solution measured by evaporating an aliquot on the surface of a 1 in. silver disk similar to the one on which the standard radium D + E was mounted. Another aliquot was prepared under the conditions under which routine samples were measured, namely in a platinum dish. The ratio of the disintegration rate to the observed counting rate gave the geometry factor for P^{32} under routine counting conditions. The geometry factor for P^{32} for these experiments was 3.9. The corresponding geometry factor for Sr^{90} (+ Y daughter) was also 3.9.

In accordance with a recent suggestion of Condon and Curtiss (2) the activity has been expressed in rutherfords (rd.), one rutherford being defined as 10^6 disintegrations per second.

Radiophosphorus, P^{32}

The P^{32} was in the form of disodium hydrogen phosphate, about 4 mgm. disodium hydrogen phosphate per mc. of activity of P^{32}. This was dissolved in water to give a solution of activity 0.65 rd. per ml. Solutions of lower activities were made by dilution of the stock solution.

Radiostrontium, Sr^{90}

The stock solution of Sr^{90} was in the form of a 0.3% solution of strontium chloride pH = 4.7. The Sr^{90} was in equilibrium with its Y daughter and the beta activity (11.7 rd. per ml.) is thus due equally to Sr^{90} (0.6 mev.) and Y^{90} (2.6 mev.). Solutions of lower activities were made by dilution of the stock solution.

Results

Lethal Concentration of Disodium Hydrogen Phosphate for Triticum vulgare Vill. var. Thatcher

Seeds of Thatcher wheat were germinated in water for 48 hr. and at the end of this time they were placed in test tubes containing a known amount of P^{32}, obtained by evaporating to dryness, in the bottom of the test tube, aliquots of a standard solution of active disodium hydrogen phosphate. Into this was delivered 0.1 cc. of Knop's nutrient (5) that had been made up lacking the usual dipotassium hydrogen phosphate. The following test tubes were set up:

Series No. 1; eight test tubes, zero radioactivity, controls.
Series No. 2; eight test tubes, 0.0065 rd. radioactivity.
Series No. 3; eight test tubes, 0.065 rd. radioactivity.

The seedlings were left until the test tubes were perfectly dry and were then placed on blotting paper shelves in clean test tubes containing 5 cc. Knop's nutrient. The seeds dried at various times but the transfer was complete by the fourth day. Most members of series No. 2 were transferred on the second and third days while the individuals from series No. 3 were transferred entirely on the fourth day.

The test tubes from which the plants had been removed were rinsed with water, then with acid, and the rinsings evaporated and counted under the Geiger counter. The average radioactivity remaining in series No. 2 was 2% but in series No. 3 it was 20%. Possibly, in this case, the fact that the plants were growing more slowly gave more of the liquid an opportunity to evaporate and remain on the walls of the test tube.

Root lengths were measured twice a day. Fig. 1 (inset) shows the variation in growth of the three groups. Average figures from each group of eight were used. At the end of the second day the roots were too coiled for further measurement and shoot lengths were measured. Fig. 1 shows the growth variation of the shoots from the 2nd to the 12th day. The individuals of series No. 3, with the exception of one, did not grow at all after being introduced into the solution but remained exactly the same length as they had been following germination in water. The one individual that grew achieved a length of 0.5 cm. and then remained stationary, finally dying. The results of this experiment suggest that a disintegration rate of 0.05 rd. (0.065×0.8) of beta particles from P^{32} (approximately 1.4 microcuries) is lethal to a Thatcher seedling. From the size of the wheat seed we can estimate that about 50% of the beta particles from the P^{32} will be absorbed by the seed (see data for actual measurements on Sr^{90} later). The average energy of the beta particles is 0.7 mev. and thus the energy dosage per seed is $\frac{1.4}{2} \times 3550$ ergs per day $= 2485$ ergs per day $\equiv \frac{2485}{83}$ r.e.p.* per day $= 30$ r.e.p. per day. For a seed

* *r.e.p. = roentgen-equivalents-physical (6).*

of 0.3 gm. weight this corresponds to 100 r.e.p. per gm. of tissue per day (3, p. 259).

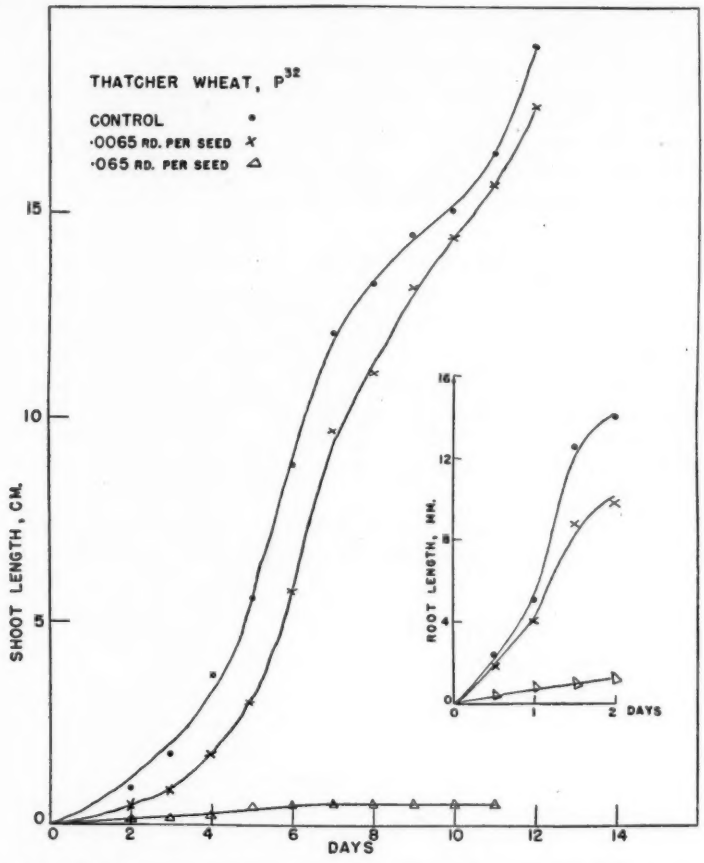

FIG. 1. *Plot of average shoot length versus period of growth for Thatcher wheat containing radioactive phosphorus, P^{32}. Inset: root length in mm. versus time in days for initial stages of growth of Thatcher seeds containing P^{32}.*

Effect of P^{32} on Thatcher, Pelissier, and Einkorn Wheats and Hannchen Barley

Additional information is given in an experiment set up mainly to provide information on the cytological and genetic effects of P^{32} on the following plants (1):

Triticum vulgare Vill. var. Thatcher ($n = 21$)
Triticum durum Desf. var. Pelissier ($n = 14$)
Triticum monococcum L. (Einkorn, $n = 7$)
Hordeum distichon L. var Hannchen ($n = 7$)

On July 8, 1947, test tubes were set up to receive the seeds as follows:

Einkorn, 24 test tubes, radioactivity 0.0065 rd.
Einkorn, 24 test tubes, radioactivity 0.00065 rd.
Einkorn, six test tubes, radioactivity zero (control).
Pelissier, 24 test tubes, radioactivity 0.0065 rd.
Pelissier, 24 test tubes, radioactivity 0.00065 rd.
Pelissier, six test tubes, radioactivity zero (control).
Thatcher, 24 test tubes, radioactivity 0.0065 rd.
Thatcher, 24 test tubes, radioactivity 0.00065 rd.
Thatcher, six test tubes, radioactivity zero (control).
Barley, 24 test tubes, radioactivity 0.0065 rd.
Barley, 24 test tubes, radioactivity 0.00065 rd.
Barley, six test tubes, radioactivity zero (control).

On July 10, seeds that had been germinated for 48 hr. were placed in the test tubes as listed above and appropriate amounts of radioactive solution added. The controls were given an equal quantity of tap water. By July 12, the radioactive solution had been absorbed by most individuals and Knop's nutrient was added. The Knop's was made up according to the usual formula except that the dipotassium hydrogen phosphate was omitted. The controls were given regular Knop's nutrient. Growth curves (average) for these plants are shown in Figs. 2 to 5. Owing to extreme heat these curves may not represent normal behavior although, at maturity, they were close enough to normal

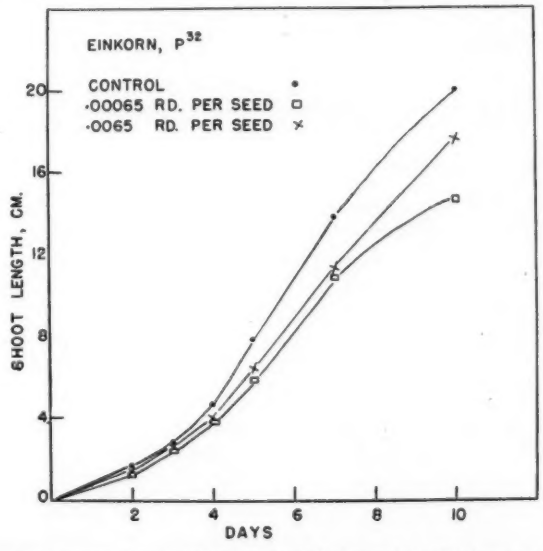

FIG. 2. *Plot of average shoot length versus period of growth for Einkorn wheat containing radioactive phosphorus, P^{32}.*

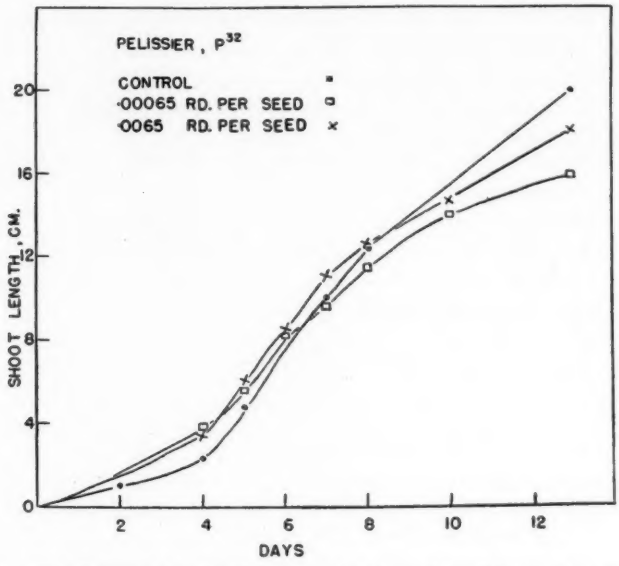

FIG. 3. *Plot of average shoot length versus period of growth for Pelissier wheat containing radioactive phosphorus, P^{32}.*

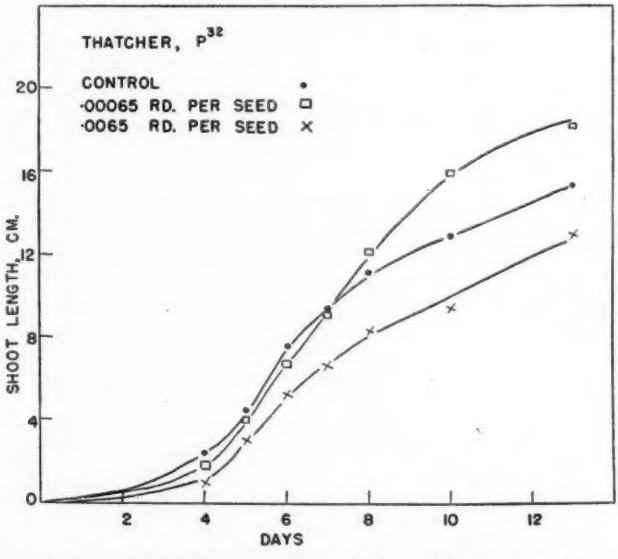

FIG. 4. *Plot of average shoot length versus period of growth for Thatcher wheat containing radioactive phosphorus, P^{32}.*

appearance that it may be assumed that the heat had no permanent effect upon the growth of the plants. The standard deviation for any given set of shoot length measurements was about 20%. It appears from these experiments that, for P^{32}, a beta activity of 0.0065 rd. is below the lethal limit for the three varieties of wheat and the one variety of barley. This is in agreement with the previous wheat experiment.

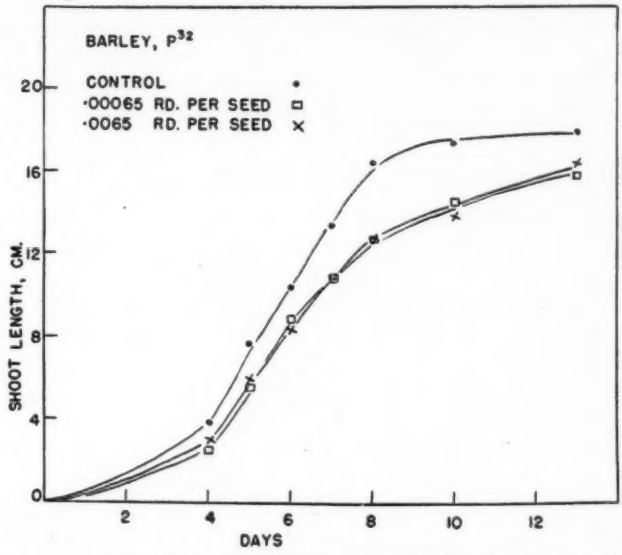

FIG. 5. *Plot of average shoot length versus period of growth for Hannchen barley containing radioactive phosphorus, P^{32}.*

Lethality Experiments for Sr^{90} (+ Y Daughter) on Wheat, Barley, and Sunflower

Five types of seed were investigated: Einkorn, Pelissier, and Thatcher wheats, Regal barley, and sunflower (an inbred variety of *Helianthus annuus* L., $n = 17$). Germination tests were run on the five plants. One hundred seeds were placed on soaked Kleenex and germination read on the first and second days. Germination had taken place in over 90% of the seeds of each variety, with the exception of sunflower, at the end of 48 hr The sunflower showed 74% germination at this time and 100% in 72 hr.

One hundred and fifty test tubes were set up in racks. The racks were darkened with black paper walls to keep some of the light from the roots. Each of the five types of seeds were set up as follows:

Six seeds in 0.1 ml. solution each, radioactivity 0.65 rd.
Six seeds in 0.1 ml. solution each, radioactivity 0.065 rd.
Six seeds in 0.1 ml. solution each, radioactivity 0.0065 rd.
Six seeds in 0.1 ml. solution each 0.33% inactive strontium chloride.
Six seeds in Knop's nutrient.

The most highly radioactive solution was 0.33% with respect to strontium chloride, the other two, 0.033% and 0.0033% respectively. The seeds in Knop's nutrient were started on blotting paper shelves but all the rest were placed in the bottom of the test tubes and 0.1 ml. of solution delivered on top of them. When the seeds had absorbed all the moisture available they were carefully removed with forceps and placed on blotting paper shelves and 5 ml. Knop's nutrient added to each test tube.

Counts of the number germinated in each group were made every day. Measurements of shoot length were also made and averages recorded. Fig. 6, for Einkorn, is typical of the curves obtained. On the 13th day after the

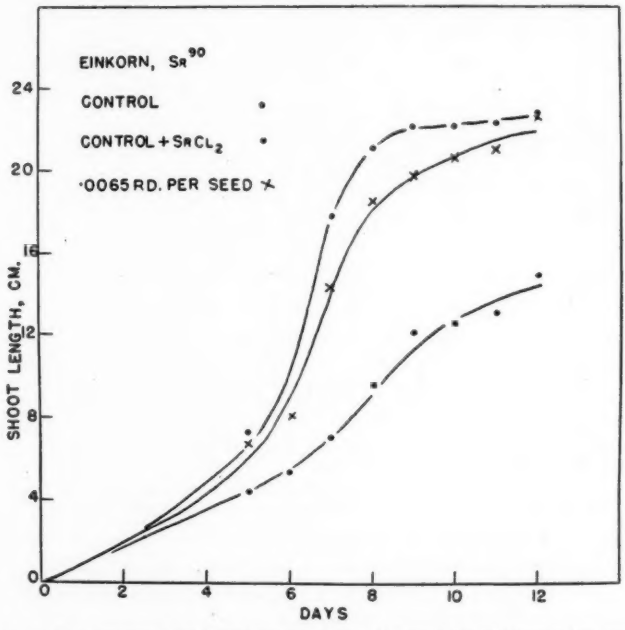

FIG. 6. *Plot of average shoot length versus period of growth for Einkorn wheat containing radioactive strontium, Sr^{90} (plus Y^{90} daughter).*

seeds were started the plants were transferred to crocks and grown in the greenhouse. The residual P^{32} in the solution was measured and indicated that the seeds had absorbed approximately 80% of the radioactivity.

The seeds given 0.65 rd. P^{32} did not grow at all, those that were started at 0.065 rd. germinated very poorly and all died although one hardy Einkorn plant grew a stem, but no roots, for a week before perishing.

The figures therefore show growth curves for 0.0065 rd. activity and the two controls. The sunflower group was an exception, appearing to withstand the higher activities better both in germination and growth. Since

it was thought that this difference might have been due in part to the thick husk of the seed, further experiments were done with the outer husk removed (see later).

These experiments indicate that an activity of 0.065 rd. of Sr^{90} (+ Y^{90}) is lethal for the above named varieties of wheat and barley whereas 0.65 rd. is lethal for sunflower.

After the experiment was in progress the pH of the various solutions was measured. The pH of the final solutions ranged from 6.5 to 8.0 but the pH of the most active initial solution was 3.8. Since the lethal effect of the most active solution might have been due in part to the pH, a further set was run in which care was taken to have the pH of even the most active solutions somewhat higher (4.7).

Further Lethality Experiments for Sr^{90} (+ Y^{90}) on Wheat, Barley, and Sunflower

Additional experiments were done with Thatcher wheat, barley, and sunflower. One set of each of these was allowed to germinate and grow for 24 hr. prior to being subjected to the radioactivity. Another set of the same species was subjected to the radioactivity immediately so that germination had to take place in the radioactive solution. These sets were run in series of five seeds each.

Series 1. Five seeds of Thatcher, 0.1 ml. solution each: radioactivity 0.65 rd.

Series 2. Five seeds of Thatcher, 0.1 ml. solution each: radioactivity 0.065 rd.

Series 3. Five seeds of Thatcher, 0.1 ml. solution each: radioactivity 0.0065 rd.

Series 4. Five seeds of Thatcher, 0.1 ml. solution each: radioactivity 0.00065 rd.

Series 5. Five seeds of Thatcher, 0.1 ml. solution each: inactive Sr^{++}.

This was also done with barley and sunflower, using pregerminated and direct treatments. In addition, a peeled set of sunflower seeds was subjected to a similar treatment.

Procedure

In the pregerminated series, seeds of the three species were allowed to germinate for 24 hr. and after measurement of the size of the root tip they were inserted into test tubes and 0.1 ml. of the various activities of strontium chloride solution added. In the direct series, 0.1 ml. of solution was added directly to the ungerminated seed in a test tube. Controls were treated similarly, 3 mgm. inactive strontium chloride per ml. being used, this being slightly in excess of the concentration of radioactive strontium chloride. After about 60 hr., modified Knop's solution (in which phosphates and sulphates were eliminated to prevent precipitation of the strontium ion) was

added. The growth was measured every 24 hr. and the average growth calculated and recorded. Fig. 7, for Thatcher, direct treatment, is typical of the curves obtained. The average growth after 310 hr. is tabulated in Table I.

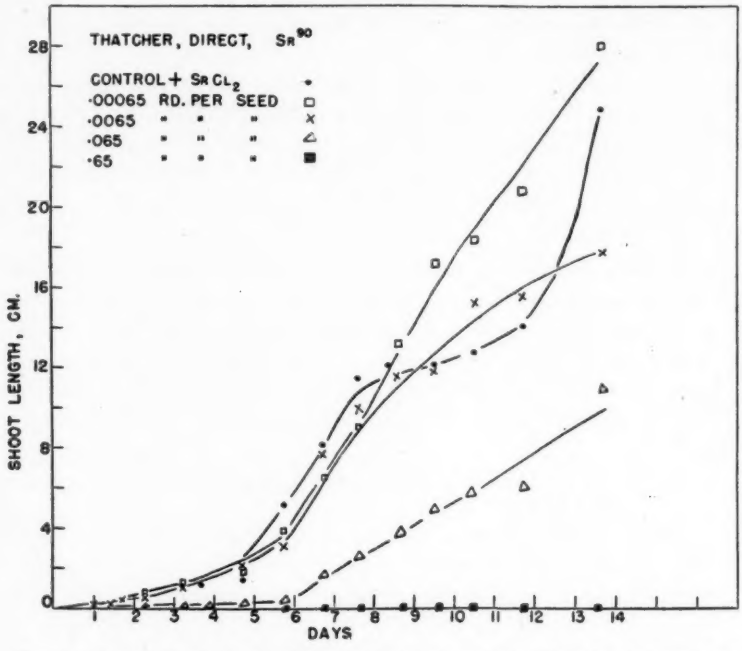

FIG. 7. *Plot of average shoot length versus period of growth for Thatcher wheat containing radioactive strontium, Sr^{90} (plus Y^{90} daughter). Active solution applied directly to the ungerminated seed.*

TABLE I

AVERAGE GROWTH AFTER 310 HR. (CM. FROM TIP OF MAIN ROOT TO TIP OF TOP LEAF)

Radioactivity (rd.)		0.65	0.065	0.0065	0.00065	Control
Thatcher	P.G.*	0.12	11.6	19.6	21.2	22.0
	D.**	0.0	7.0	18.0	24.8	27.5
Barley	P.G.	0.12	12.0	18.4	21.0	21.5
	D.	0.0	12.2	17.9	21.0	22.0
Sunflower (unpeeled)	P.G.	0.1	6.8	13.1	11.2	14.0
	D.	0.0	1.5	13.6	8.8	15.0
Sunflower (peeled)	P.G.	0.1	9.0	10.4	12.2	13.5
	D.	0.0	2.5	11.2	11.5	10.0

* *P.G., pregerminated.*
** *D., direct.*

In these experiments, it appears that 0.65 rd. is completely lethal in both direct and pregerminated experiments while 0.065 rd. is strongly inhibitory. Inhibition appears to be somewhat greater in the direct than in the pregermination experiments. The amount of Sr^{90} absorbed in these experiments was not measured so that the above figures give only an approximate lethal limit. The plants appeared to have a somewhat greater resistance to activity than in the first strontium lethality experiments, possibly owing to the more favorable pH in this set of experiments, but possibly owing also to slightly different growing conditions. At all events, we can say that the lethal limit is not very different from that for P^{32} and is about 0.1 rd. per seed. Cytological effects were noted and are reported elsewhere.

The Thatcher, barley, and sunflower seeds weighed 0.29, 0.29, and 0.66 gm. respectively. In order to estimate the fraction of beta particles absorbed by the seed the decrease in activity of a small evaporated drop of Sr^{90} (+ Y) solution, on being covered by a split seed, was measured. About 40% of the beta particles were absorbed by Thatcher and barley and 55% by sunflower. Before making any exact calculations, the distribution of activity in the seed at various times is required and it is proposed to measure this in future experiments. One would also need to estimate the absorption, by the seed, of β-particles from the solution.

Toxicity of Inactive Strontium Solutions

One hundred seeds of Thatcher wheat were germinated in each of the following solutions:

1. Strontium chloride 0.01%
2. " 0.08%
3. " 0.5%
4. " 1.0%
5. Strontium nitrate 0.01%
6. " 0.08%
7. " 0.5%
8. " 1.0%
9. Tap water
10. Modified Knop's nutrient made as follows:

Strontium nitrate	0.08 gm.
Potassium nitrate	0.04 gm.
Magnesium nitrate	0.02 gm.
Ferric nitrate	Trace
Water	100 cc.

The concentrations were chosen to straddle the concentration of 0.33%, previously used with radioactive strontium chloride, so as to determine whether or not the presence of the salt contributed to the lethal effects observed. The concentration of 0.08% was chosen because it is the percentage used in the modified Knop's solution. Germination results were as follows:

Salt		Germination, % After 24 hr.	After 48 hr.	After 72 hr.
Strontium chloride	0.01%	50	94	98
	0.08%	74	98	98
	0.5%	78	97	97
	1%	21	75	87
Strontium nitrate	0.01%	79	97	97
	0.08%	54	97	99
	0.5%	22	90	96
	1%	44	86	93
Tap water		30	92	97
Modified Knop's		34	88	97

From these results it can be concluded that as far as germination is concerned, the only salt showing any appreciable effect is strontium chloride, 1%. Here there seems to be a definite, though small, inhibition of germination. It appears fairly certain that the 0.33% concentration used in the work described would have no retarding effect on germination.

Trelease and Trelease report in their investigation of magnesium injury of wheat (9) that the characteristic deformities of this injury do not manifest themselves until the appearance of the third leaf. Accordingly it was decided to raise two germinated seeds from each group in test tubes.

The seedlings were placed on blotting paper shelves and 10 ml. of solution, of the same concentration as that in which they were germinated, was added so that their growth habit in this solution could be watched.

Up until the 10th day of growth no adverse effects were noted on Thatcher seedlings grown in approximately 0.3% solutions of stable strontium nitrate and stable strontium chloride. Seedlings grown in 1% solutions of these compounds showed retarded growth and all died between the 24th and 32nd days. On the 32nd day the condition of the individuals was as follows (figures are average of two individuals):

Solution	Conc., %	Height of plant, cm.	Appearance
Strontium chloride	1	—	Dead
"	0.5	13	First leaf yellow
"	0.08	15	First leaf brown
"	0.01	19	First leaf yellow
Strontium nitrate	1	—	Dead
"	0.5	14	First leaf yellow
"	0.08	15	First leaf dead
"	0.01	18	First leaf brown
Tap water		24	Healthy
Modified Knop's (strontium replacing calcium)		28	Healthy

The number of individuals used in this experiment does not permit definite conclusions with regard to the ultimate toxicity of strontium compounds upon Thatcher wheat, but the results indicate that retardation of growth in the early seedling increases with increasing concentration of the strontium salt used. Further, a concentration of strontium nitrate of 0.08% apparently exerts no effect when used in a nutrient solution containing magnesium salt.

The injury sustained by the plants, apart from stunting, was uniform. The first leaf became yellowed, then withered and died. The second and third leaves were healthy. This suggests that the plant removed the strontium from the solution and that the building up of the concentration in the first leaf was lethal to this leaf.

Distribution of Radioactive Elements in Plants

An attempt was made to compare qualitatively the distribution of Sr^{90} and P^{32} ions in Thatcher wheat.

The seedlings and plants used in this study were obtained from previous experiments on the lethal effects of the two radioactive isotopes mentioned. The seeds were germinated in water for 48 hr., removed to test tubes, and treated with radioactive solutions with activities of the order of 4×10^5 disintegrations per minute.

Radioautographs were obtained by fixing the plant to a glass plate with cellophane tape and then placing it on a Process film, the plant being adjacent to the emulsion side of the film. The film was exposed for 48 hr. and then developed with Kodak D72 developer.

The radioautograph of a 12-day-old wheat seedling grown in P^{32} solution showed that the phosphorus was distributed fairly uniformly throughout the whole plant and that the activity was particularly high in the seed. The radioautograph of a 35-day-old plant in P^{32} showed a general distribution of activity, what little concentration there was occurring at the leaf tip. There appeared to be no difference between young and old leaves. The radioautograph of a 40-day-old plant, which had been treated with radioactive strontium chloride in its early stages of growth and then grown in soil in a pot, showed quite a different result. The activity was all concentrated in the first two leaves of the plant, the concentration in the first leaf greatly exceeding that in the second. It thus appears that the plant gets rid of the strontium chloride, not a normal plant nutrient, in the first two leaves.

Acknowledgments

We wish to record our indebtedness to the National Research Council of Canada and to Dean B. Cowie of Washington, D.C., for support of this work.

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A SUBSTANCE IN THE INTERCELLULAR SPACES OF WHITE MUSTARD ROOTS THAT REDUCES ALKALINE SILVER[1]

By R. G. H. Cormack[2]

Abstract

White mustard roots when treated with a slightly alkaline solution of silver nitrate (Tollen's reagent) show, on sectioning the meristem, the accumulation of small black stained particles in the intercellular spaces and intervening cell walls. The production of these particles in the intercellular spaces of treated roots and their complete absence in those of untreated roots indicates the presence of a substance capable of reducing alkaline silver. The presence of this substance strengthens the viewpoint that in the meristem radiating rows of intercellular spaces in white mustard roots provide for the more rapid movement of soluble materials from differentiating vascular strands to the outside. Thus cell position as related to a more accessible food supply is an important adjunct to the general problem of cell development and cell behavior.

Introduction

In order to synthesize new protoplasm, meristematic cells require a continuous supply of food. How this is accomplished in the apical meristem of the root, where the dividing cells are situated some distance beyond the vascular system, is a problem that has provoked considerable interest. Although it is now well established (5, 6, 7, 15) that the sieve tubes differentiate well down into the meristematic tip it is still a matter of conjecture how the soluble materials that they carry reach the actively dividing cells. In a long series of publications (8, 9, 10, 14), Priestley and his students conclude that the intercellular spaces and cell walls are the natural channels of food transport from the ends of differentiating vascular strands to the dividing cells. In accordance with this view it follows that the meristematic cells nearest the source of supply will be better nourished than those situated near the surface.

Certain observations obtained in a study of developing epidermal cells in white mustard roots lend considerable support to this view of food transport as visualized by Priestley and his school of workers. In the root of this plant (3) the epidermis is differentiated at an early stage into alternating rows of long and short cells. The long cells vacuolate early and do not ordinarily produce root hairs, while the short cells vacuolate later and to a lesser extent and produce hairs normally. In a later study (4) these differences between short and long cells are explained on a basis of differences in cell position as related to a more accessible food supply. For instance, as seen in transverse view each short cell is situated in direct line with a row of intercellular spaces within the cortex, while the long cells are not associated with intercellular spaces at any time in their development.

[1] *Manuscript received February 3, 1948.*
Contribution from the Department of Botany, University of Alberta, Edmonton, Alta.

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Although the existence of a 'nutritive sap' is highly probable, no one, as far as the present writer is aware, has demonstrated the actual presence of soluble materials in the intercellular spaces. Because of the delicate nature of the root meristem and the extremely small size of the intercellular spaces it is obvious that the problem is not an easy one. The solution of this problem would be infinitely easier if it were possible to test directly for solutes in the spaces of living tissue, but this necessitates cutting, which means the escape of liquids from the spaces and their rapid spread over the cut surface. Another method is to produce a chemical reaction within the spaces leaving the root intact. This method has its difficulties too. For instance, many reagents that give a definite reaction *in vitro* are not suitable when applied to plant tissue, either because of their destructive action on the protoplasm and cell walls or because the reaction requires strong heating, which has the same effect. Moreover because of the small size of the spaces there may not be a sufficient amount of the substance for which the test is being made to produce a positive reaction.

Since the existence of a 'nutritive sap' in these spaces is speculative and since nothing is known of its chemical nature it is first necessary to test for a number of substances having a common reaction and one that is easily recognizable rather than to test for a specific substance. Certain substances that fall naturally into a category of this kind are those that are easily oxidized, thereby acting as reducing agents. In this class of organic substance are included certain sugars that have an aldehyde or ketone group (1). When treated with the appropriate test reagent, reducing substances yield a colored and characteristic precipitate. Thus the present paper records the results of a microchemical investigation designed to detect a reducing substance in the intercellular spaces and intervening cell walls. It lays no claim to represent a finished piece of work, but is intended to show one method of testing for an intercellular substance and to suggest ways and means of identifying its chemical nature. The testing for other substances in these intercellular spaces is still in progress.

Materials and Methods

Because of their narrow diameter, and the conspicuous development of intercellular spaces, seedling roots of white mustard (*Brassica alba* (L.) Boiss.) provide suitable material for this study. Seeds of this plant germinate readily between moist blotters at room temperature (22° C.). When the seedling roots reach a length of 5 to 10 mm. they are considered ready for treatment with the test reagent.

As mentioned above many of the best known test reagents are not satisfactory for a microchemical study of this kind. This is true for Fehling solution, Flückiger, and other reagents of a similar nature and all those that require strong heating. In every case, the reaction is so drastic as to render the meristematic tissue unsuitable for microscopic study. After considerable experimentation a modification of Tollen's reagent (12) appeared to be most

suitable for this purpose, since it is only slightly alkaline and does not require heating at a high temperature. It is prepared by adding concentrated ammonium hydroxide to a 3% solution of silver nitrate until the precipitate that forms just redissolves. According to Tuba *et al.* (13) silver nitrate is very easily reduced in ammoniacal solution, much less readily in neutral solution, and in acid solution with comparative difficulty.

Preliminary tests showed that the reagent penetrates the tissues rapidly and the length of time the material remains in the solution up to a maximum of 24 hr. appears to make little or no difference. The usual procedure is as follows: whole seedlings are immersed in the reagent in a test tube and placed in the dark for not longer than 18 hr. At the end of this time the seedlings have turned a dark brown color. They are then thoroughly washed in distilled water. After washing, but while still in water, the seedlings are exposed to full sunlight for four hours, either at room temperature or in a water bath at 37° C. The roots are then severed from the seedlings, dehydrated, embedded in paraffin, and cut transversely at 10 μ beginning at the extreme apex of the root. Since the sections are already stained brown by the reagent, no further staining is usually required. However, sections cut at 5 μ and stained with Delafield's haematoxylin are more suitable for cell wall study and for making photomicrographs.

Results

As already pointed out (Cormack, 1947 (4)) diamond-shaped intercellular spaces originate at an early stage in the meristem and become increasingly conspicuous at successively higher levels. In the present study of serial transverse sections they are first observable at a distance of 80 to 100 μ from the root apex. They are extremely small measuring 3 to 4 μ across their widest diameter. At this level the epidermal cells are all alike in size and shape and are scarcely distinguishable from the innermost row of root cap cells. Differentiation of the epidermis into long and short cells is first evident at about 120 to 150 μ above the root apex. By this time every section shows two well defined rows of diamond-shaped spaces in the cortex and occasionally a much smaller triangular-shaped space at the base of a short cell. This condition of the meristem taken at a somewhat higher level, approximately 250 μ above the root apex is clearly shown in Fig. 1. At this level the section is surrounded by two complete rows of small transparent root cap cells. Within the band of root cap tissue lies the single row of epidermal cells. The wedge-shaped cells each in contact with two cortical cells are the short cells, while the radially elongated cells situated between two short cells are the long cells. In the cortex the two rows of radially placed diamond-shaped spaces are prominent as are also a few triangular-shaped spaces in the epidermis. The cortical spaces are appreciably larger than at their origin and measure 7 to 9 μ across their widest diameter. While the cortical cells and short epidermal cells are densely filled with protoplasm and contain a prominent nucleus the long epidermal cells are beginning to show the first

signs of vacuolization. Differentiation of sieve tube elements in the stele is just beginning at this level.

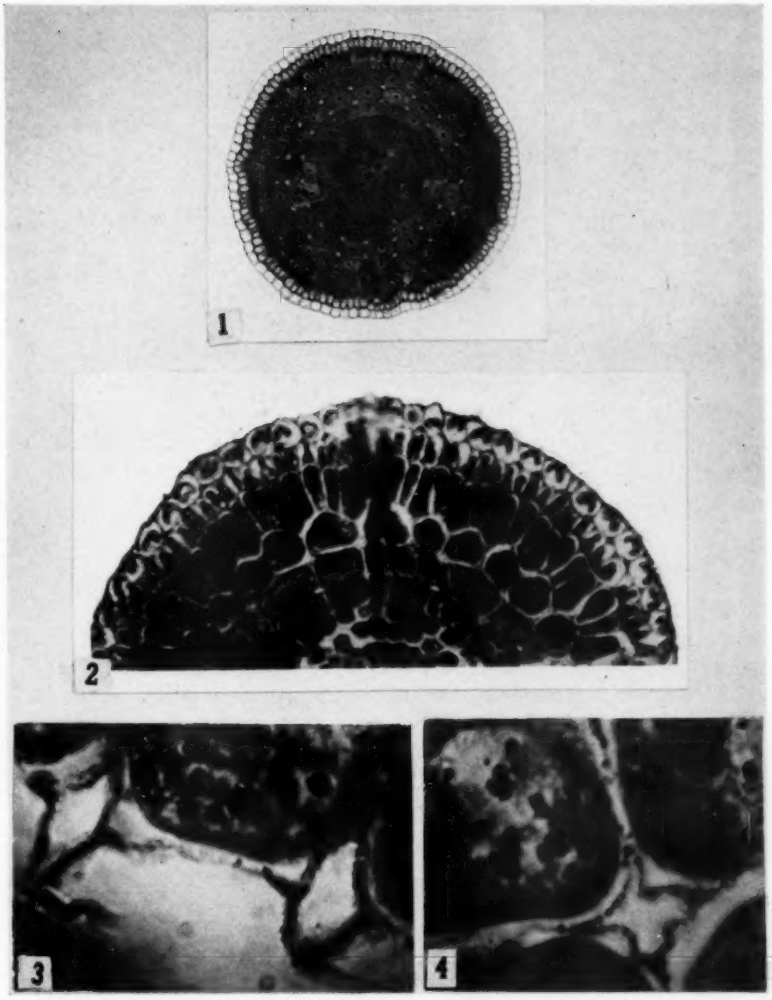
Casual examination of transverse sections of roots treated with Tollen's reagent show that they are exactly comparable to those of control roots, killed and fixed with CRAF solution. It is thus evident that Tollen's reagent kills and fixes the meristematic tissue rapidly, without injury to the delicate cell walls and causing little or no plasmolysis. The condition of the meristem of a treated root at approximately 175 μ from the root apex is shown in Fig. 2.

However, the most noteworthy feature in transverse sections of treated roots is the occurrence of small but well defined black stained bodies or particles in the intercellular spaces and aggregations of similar particles in the adjacent protoplasts. In general, they occur in all spaces throughout the meristematic region but they appear more conspicuously within a range extending from about 150 μ to 400 μ above the root apex and here they appear more numerous. Within this range some spaces contain more stained particles than others, but seldom, if ever, do they completely fill the whole space. When viewed with an oil immersion lens of sufficient resolving power these minute stainable particles are observed adhering to the surface of the walls forming the space and are observed also in the walls themselves. This feature is illustrated in the highly magnified photomicrographs, Figs. 3 and 4. Fig. 3 shows the condition of the cortex at approximately 200 μ from the root apex. Here, fortunately, but quite by accident, the protoplasts of three radially placed cells have dropped out of the section, thus exposing the walls, which have been left intact. Numerous small black stained bodies are clearly visible in both spaces, and in the protoplasts. Fig. 4 represents a small portion of another section from the same root, but at a somewhat higher level. Some plasmolysis has occurred in these cells causing the protoplasts to draw away very slightly from the cell walls. Once again numerous small black stained particles are observable in the diamond-shaped space and in the thin cell walls.

It may be noted that no particles corresponding to those found after treatment with Tollen's reagent are observed in the intercellular spaces of untreated roots, whether the sections are stained with haematoxylin or not.

Discussion

From the nutritional standpoint the position of actively dividing cells in relation to the food supply is a matter of considerable interest. Although the root meristem has been extensively studied by numerous investigators and the developmental stages clearly outlined in a recent review by Sifton (11), little is actually known concerning the movement of nutrients in this region. In this connection, Priestley (9) is of the firm belief that the "carbohydrate walls cleaving the meristematic mass are of the first importance, and are the channels along which these food materials reach the centres of protoplasmic synthesis". Also "that so long as the walls and intercellular spaces are filled with sap, there will be no difficulty in the transfer of solutes by this path to the actively growing cells". More recently Borgström (2) emphasizes the



FIGS. 1-4. *Photomicrographs of transverse sections through the meristem of white mustard roots.* FIG. 1, × *130. Transverse section approximately 250 μ from apex of untreated root, showing two rows of root cap cells, differentiation of the epidermis into short and long cells, and prominent diamond-shaped intercellular spaces in the cortex.* FIG. 2, × *300. One-half cross section of a treated root approximately 175 μ from the root apex, showing marked plasmolysis in the two rows of root cap tissue, very slight plasmolysis in the epidermis and none in the cortical cells adjoining the spaces.* FIG. 3, × *2500. Transverse section about 200 μ from apex, black-stained particles in two radially placed intercellular spaces and in the cell walls. In cutting, the protoplasts on one side of the spaces have dropped out of the section, but their walls forming the spaces are intact.* FIG. 4, × *2500. Transverse section of the same root at a slightly higher level showing a single space. Black-stained particles are conspicuous in the space and in the cell walls. The protoplasts have drawn slightly away from the cell walls.*

importance of the cell walls in the transverse movement of auxins in plant tissues. From the results of numerous experiments he concludes that the walls in the transport direction must show a favored stretching.

The results of the present study demonstrate for the first time the occurrence of a substance in the intercellular spaces, and one capable of reducing alkaline silver. That this substance may be a reducing sugar seems highly probable, but since there may be a number of substances responsible for this reaction the solution of this particular aspect of the problem awaits further investigation.

The criticism might be raised that diffusion of the reducing substance may have occurred from the surrounding cells into intercellular spaces during the treatment. That this is the cause for the presence of a reducing substance in the intercellular spaces and intervening cell walls is quite unlikely. For at a level in the meristem where no plasmolysis occurs, particles are extremely numerous in all the spaces, while at somewhat higher levels where some plasmolysis occurs not a single particle is visible between the contracted protoplasm and the cell wall of individual cells forming the space.

The early development of intercellular spaces in the meristem of white mustard roots, somewhat previous to the differentiation of the epidermis into short and long cells, strongly suggests that from the very beginning they provide a more rapid movement of food to the outside. Although the detection of an intercellular substance strengthens the view that these radiating rows of spaces are the pathways for food movement, it does not prove this point. However, this assumption gives an intelligible explanation of the ability of the short epidermal cells to remain richly protoplasmic long after the long epidermal cells have become highly vacuolated. Moreover, as shown in roots of certain other plants, namely tomato and corn (4), where radiating rows of spaces either do not exist or do not extend completely through the cortex, the epidermis is not differentiated into long and short cells. In these roots all the epidermal cells are alike and they all begin to vacuolate at a point much closer to the root apex than do the short epidermal cells of white mustard roots.

Acknowledgments

I wish to thank Dr. M. M. Cantor of the Department of Biochemistry for preparing the Tollen's reagent and for his friendly interest in the problem. My thanks are also due to Dr. R. B. Miller of the Department of Zoology and to Miss L. L. Kennedy of this department for their kindness in taking the photomicrographs.

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NOTES ON SEED-BORNE FUNGI

V. *CHAETOMIUM* SPECIES WITH DICHOTOMOUSLY BRANCHED HAIRS[1]

By A. J. Skolko[2] and J. W. Groves[3]

Abstract

The large number of isolates of *Chaetomium* species obtained from agricultural seeds has made possible the critical study of some sections of the genus. In this paper the species with dichotomously branched hairs are considered. Of the six species previously recognized in this group, four have been isolated from seeds, *C. elatum* Kze. ex Fries, *C. dolichotrichum* Ames, *C. funicolum* Cooke, and *C. indicum* Corda. Two new species are described, *C. erectum* and *C. reflexum*, making a total of eight recognized species in this group.

The Genus *Chaetomium*

The genus *Chaetomium* was erected in 1817 by Kunze based upon *Chaetomium globosum* Kze. The present day concept of the genus includes those species with subglobose to elongate, colored, superficial perithecia that are provided with an ostiole. The perithecial wall is membranous and cellular and from the cells of the wall variously modified hairs are produced. The lateral hairs are frequently of different form from those borne at the summit of the perithecium. The terminal hairs may be spinelike, arched, flexed, coiled, circinate, or variously branched. Often secondary terminal hairs are developed with maturity and these may differ from the primary hairs. The asci are thin-walled and evanescent, usually clavate, sometimes cylindrical, typically eight-spored. The spores are simple, colored, typically lemon-shaped, and extruded through the ostiole either in an irregular mass or in cirrhi. Variations in spore shape range from globose to fusiform, triangular, or, in one case, square.

Since Kunze first established the genus, a large number of species have been described but many of these have been placed in synonymy or have been shown to be misdeterminations. Among the more important early contributions may be mentioned those of Zopf (1881 (18)), Palliser (1910 (12)), and Bainier (1910 (2)). In 1915 Chivers' monograph of the genus appeared and of the 114 species and 14 varieties that had previously been referred to the genus, he retained only 28, of which 11 were species described by him. Since Chivers' paper only a few new species have been added to the genus. Petrak (1915 (13)) described *C. fiscicolum*. Swift and Povah (Swift, 1929 (14)) described *C. subterraneum*, which Tschudy (1937 (16)) subsequently found

[1] *Manuscript received February 19, 1948.*

Contribution No. 935 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

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to be identical with *C. globosum*. Garbowski (1936 (5)) established *C. tortuosum* and Tschudy (1937 (16)) described *C. ochraceum*, *C. cancroideum*, and *C. globosum* Kze. var. *affine*. Greathouse and Ames (1945 (6)) added *C. dolichotrichum*, *C. pachypodioides*, and *C. microcephalum*. Hughes (1946 (8)) described a species with four-spored asci, *C. tetrasporum*.

In the course of our examination of various commercial and registered agricultural seed stocks, members of the genus *Chaetomium* were amongst the commonest of the fungi isolated. The seed in all cases was first surface sterilized with a standard chlorine solution as described by Groves and Skolko (1944 (7)), and then plated on malt agar. It is by no means certain that the isolates of *Chaetomium* thus obtained are surface borne and capable of withstanding this sterilization or whether they are carried over in the seed as internal mycelium. Norris (1945 (10)) has claimed that *Chaetomium* spores are especially resistant to chlorine disinfection. Although *Chaetomium* species are usually regarded as being saprophytic and of particular economic importance as deteriorators of fabric, leather, and paper products, it has been observed that seed samples heavily infected with *Chaetomium* show a correspondingly low germination. The musty odor of these seed stocks is characteristic. It is frequently possible to distinguish cultures of *Chaetomium* by this odor even before any evidence of fruiting is visible.

There are few records of *Chaetomium* species isolated from seed. Garbowski (1936 (5)) lists *C. globosum*, *C. spirale*, and *C. tortuosum* isolated from seed of *Pinus sylvestris*. Orton's bibliography (1931 (11)) of seed-borne parasites lists *Chaetomium* sp. as being isolated from seeds of corn (*Zea Mays*) and from wheat (*Triticum aestivum*). Tullis (1936 (17)) isolated *Chaetomium* spp. from discolored rice kernels. Chilton (1942 (3)) reported the occurrence of *Chaetomium* sp. in seed of clover. Tervet (1945 (15)) found *Chaetomium* sp. on soybeans, and Arndt (1946 (1)) found a species of *Chaetomium* on cotton seed. We have isolated some 15 species from a variety of vegetable and field crop seeds; of these four are considered to be new. Although the pathological significance of these species still remains obscure, the large number of isolates has provided an opportunity for a critical study of some sections of the genus and has provided many new records.

It has been possible to examine a number of the exsiccati cited by Chivers. For the most part the exsiccati in the mycological herbarium of the Dominion Department of Agriculture, Division of Botany and Plant Pathology, Ottawa, Canada, (DAOM), agree with those examined by Chivers. In a number of cases it is obvious that the original collection was a mixed one. This has undoubtedly added to the confusion. Examples of such instances are noted in the discussion of the various species. Type or authentic material of most valid species has been examined, and although less than half of the recognized species of *Chaetomium* have been isolated from seed, since it has been possible to examine most of the types, a key to the genus has been prepared to include

the more recent species. In this paper the key to those species with dichotomously branched hairs is presented. Full descriptions are given only for species that we have isolated from seed.

Reference is frequently made in descriptions of species of *Chaetomium* to terminal or lateral hairs with elongated, hyaline tips that appear collapsed. It has been observed that in freshly made mounts of a number of such species these hyaline tips are greatly inflated, suggesting that under favorable conditions of humidity this is the normal appearance but when placed in a mounting medium the inflated tips collapse. An irregular opening may frequently be observed in the wall of the hair just below the narrow portion of the tip, which is suggestive of excessive internal pressure. Examination of unmounted perithecia by reflected light often discloses sparkling tips on the hairs. This may in part be a result of the refractive nature of the inflated tips and in part to the hyaline character of the tip alone. It is possible that the irregular crystalline projections on the hairs may be responsible for the reflection of light from the tips for it is sometimes found that these crystals are most numerous toward the tip.

Little use has been made of the character of the ascus in the separation of species. The difficulty of observing the early evanescent asci makes them of doubtful value in this connection.

Cultural characters referred to in the following descriptions apply to the appearance of the colony on 2% malt agar plates kept at room temperature in diffuse light. Most cultures have been grown on filter paper and have been deposited in the herbarium of the Division of Botany and Plant Pathology at Ottawa.

Prior to 1937 only four species with dichotomously branched hairs were recognized, *C. elatum* Kze. ex Fries, *C. indicum* Cda., *C. funicolum* Cke., and *C. cuniculorum* Fckl. *C. elatum* and *C. cuniculorum* remain sufficiently distinct although the latter species appears to be less common than early reports suggest and hence is not too well understood. The two other species, *C. indicum* and *C. funicolum*, have obviously presented difficulties in their separation. This is perhaps understandable in view of the numerous intermediate forms that exist and the fact that new species have since been segregated from what formerly, in all likelihood, would have been considered one or other of these two species. Since 1937 two such species have been recognized and in the present paper two others are added. They differ essentially in the presence or absence of terminal, unbranched hairs, in the character of the dichotomously branched hairs, and in the size of the perithecium. At one end of the series is *C. funicolum* with simple terminal hairs and dichotomously branched hairs with the branches at acute angles, roughened, and with more or less straight, short internodes. Close to this species is *C. dolichotrichum* in which the hairs are more graceful, with long tips, and with the branches of the dichotomous hairs almost at right angles to the axis, smooth or nearly so, usually slightly reflexed, with long internodes. The remaining species either lack simple terminal hairs or, if present, they soon

become obscured. *C. indicum* is rather larger than the others, with regular and repeatedly dichotomously branched hairs, the branches arising at right angles to the axis and forming a regular network; *C. erectum* with rigid, erect hairs and few, short, blunt branches; *C. reflexum* with short, stout, arcuate or curved hairs with the short, blunt branches strongly recurved; and *C. cancroideum* with graceful, ascending, terminal hairs, frequently dichotomously branched with the branches arising at an acute angle and incurved to give a 'crab claw' appearance. In culture these species differ widely and within some of the species there are sufficient cultural differences to suggest that further separations may be expected.

KEY TO THE SPECIES OF *CHAETOMIUM* WITH DICHOTOMOUSLY BRANCHED HAIRS

A. Branches of terminal hairs essentially straight.

B. Unbranched terminal hairs present at maturity (in addition to dichotomously branched hairs), conspicuous, usually projecting beyond the mass of branched hairs.

C. Perithecia large, up to 450μ wide; terminal hairs coarsely roughened, stout, 5–8μ wide; spores lemon-shaped, colored, large, 10–11 × 7–8μ..... *C. elatum*

CC. Perithecia medium size, 370μ; branches of terminal hairs anastomosing; spores elliptical or spindle-shaped, 10–12 × 7–9μ..... *C. cuniculorum*

CCC. Perithecia small, not exceeding 200μ in width; spores oval to ovoid, less than 7μ long.

D. Branched hairs smooth or slightly roughened, branches few with long internodes, widespreading and sometimes slightly reflexed; unbranched hairs graceful, long projecting, tapering gradually to a long tip..... *C. dolichotrichum*

DD. Branched hairs coarse, often with rough projections, branches at acute angle and with short internodes; unbranched hairs rigid with rapidly tapering tip, projecting only a short distance beyond the mass of branched hairs..... *C. funicolum*

BB. Unbranched terminal hairs absent or obscure at maturity (may be present in younger stages).

C. Perithecia up to 200μ wide; terminal hairs repeatedly and regularly branched forming a close network, hairs roughened by numerous blunt projections.... *C. indicum*

CC. Perithecia not more than 140μ wide; terminal hairs rigid with only a few short branches near the top, internodes short, hairs smooth with few sharp projections at the blunt, hyaline tip..... *C. erectum*

AA. Branches of terminal hairs regularly curved.

B. Terminal hairs straight with incurved branches, producing characteristic 'crab claw' effect; perithecia 175μ wide..... *C. cancroideum*

BB. Terminal hairs arcuate with branches strongly reflexed, perithecia not over 125μ wide..... *C. reflexum*

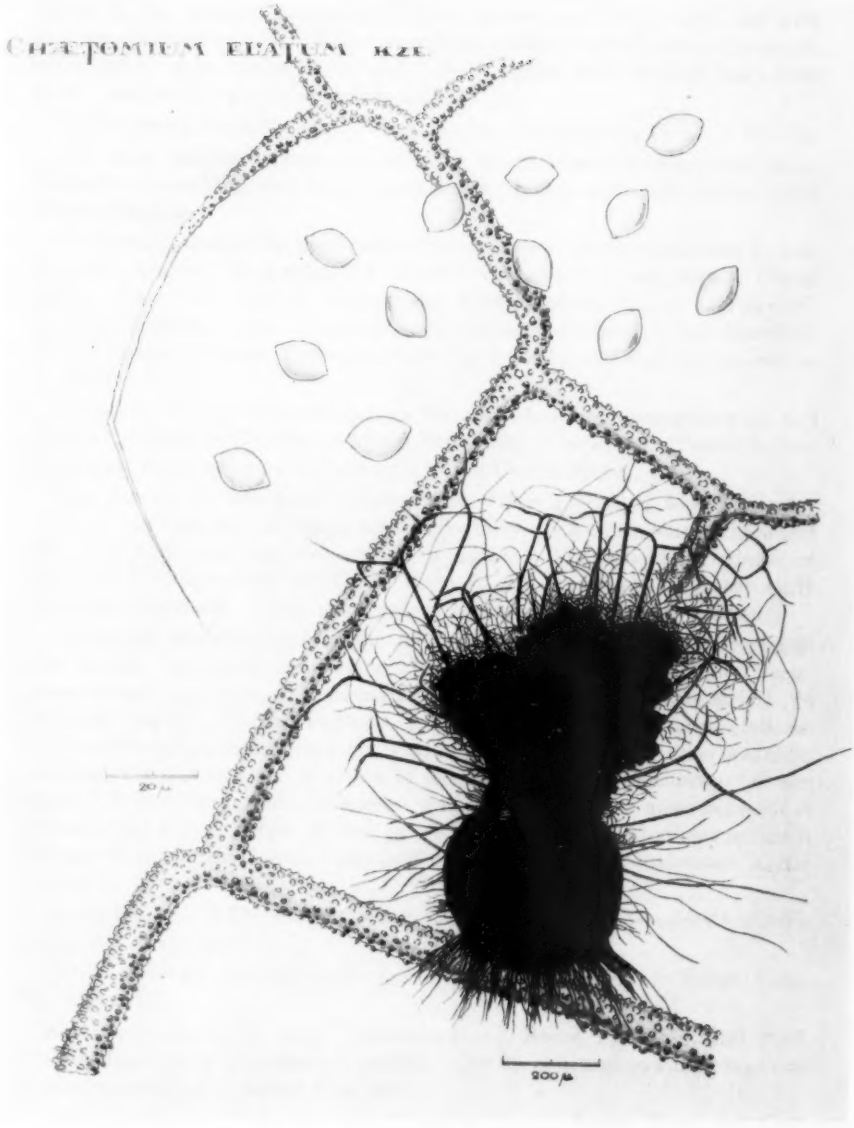
Chaetomium elatum Kze. ex Fries (Plate I) Deutsch. Schw. 8 : 3. 1818.

Culture at first white, becoming yellowish, with much aerial mycelium.

Perithecia black, subglobose or ovoid, rather large, up to 500μ long and 450μ wide, produced late, erratic, and frequently covered by white aerial mycelium.

Lateral hairs unbranched, straight or slightly flexed, roughened by irregular projections, about 4μ wide at base, ending in a blunt rounded tip.

Terminal hairs: simple, unbranched hairs present. Branched primary hairs coarsely roughened, dark olive-brown, stout, 5–8μ wide, several times


CHAETOMIUM ELATUM KZE.
20 μ
200 μ

dichotomously branched (the branching is not strictly dichotomous in that one branch arises slightly below the other and the main axis continues through making a right-angled turn to form a second branch). Secondary hairs similar to the primary except much more narrow and not so dark and with the branching less regular. Sometimes the secondary hairs become alternately branched at right angles to the axis. Both lateral and terminal hairs arise from a rosette of cells of the perithecial wall.

Spores lemon-shaped, dark olive, umbonate at both ends, 11–13 × 9–9.5μ.

The large perithecia together with the broad, coarsely roughened hairs, distinctive branching, and large, lemon-shaped spores make this species easily distinguishable.

Chaetomium elatum has been isolated from seeds of *Apium graveolens* L. var. *dulce* DC. (celery), *Beta vulgaris* L. (beets), *B. vulgaris* L. var. *cicla* L. (Swiss chard), *Cucurbita Pepo* L. (pumpkin), *Daucus carota* L. var. *sativa* DC. (carrot), *Medicago sativa* L. (alfalfa), *Petroselinum hortense* Hoffm. (parsley), *Pisum sativum* L. (peas), *Raphanus sativus* L. (radish), and *Trifolium hybridum* L. (alsike).

It has been isolated from seeds from Ontario, Manitoba, Saskatchewan, and British Columbia in Canada, and from New Jersey, Connecticut, Pennsylvania, Michigan, Washington, and California in the United States.

The citation for the name *Chaetomium elatum* presented some difficulty owing to the fact that the name was cited differently by different authors and the early literature was not readily available. Through the kindness of Dr. S. P. Wiltshire and Dr. G. R. Bisby it was possible to have the early literature examined. They informed us regarding *C. elatum* as follows:

"*C. elatum* was described in the folder accompanying Lief. 8 of Schmidt and Kunze, Deutschl. Schwämme, 1818, as follows: 'CLXXXIV *Chaetomium elatum:* sporangio subturbinato, pilis circa basin simplicibus strictis, in superfice rigidis ramosis implexis longissimis sporidiis oviformi-globosis. G. Kunze monographia hujus generis adhuc inedita.' From the last sentence, and from the fact that the specimen of No. 184 is labelled '*Chaetomium elatum* Kunze', it is evident that the species was *C. elatum* Kunze apud Schmidt & Kunze; now it is *C. elatum* Kunze ex Fr. The sentence quoted also makes it evident that one can follow Fries and cite the genus as *Chaetomium* Kunze ex Fr."

Exsiccati.—Ell. & Ev. Fung. Columb. *621*; de Jacz. fung. Rossiae *83*; Roum. Fung. Sel. Gall. *1428*.

Sub *C. atrum* Lk. var. *distinctum* Roum. (syn. *C. elatum* Kze.): Roum. Fung. Sel. Gall. *3883*.

Sub *C. chartarum* Ehr. (syn. *C. globosum* Kze.): Roum. Fung. Sel. Gall. *1090*. Chivers found only *Stachybotrys lobulata*. Our specimen shows abundant and typical material of *C. elatum* Kze. only.

Sub *C. comatum* (Tode) Fr. (syn. *C. elatum* Kze.): Roum. Fung. Sel. Gall. *975*: D. Sacc. Myc. Ital. *841*.

Sub *C. Libertii* Roum. et Pat. (syn. *C. elatum* Kze.): Roum. Fung. Sel. Gall. *2376*.

Sub *C. pannosum* Wallr. (syn. *C. elatum* Kze.): Roum. Fung. Sel. Gall. *61;* a collection in the mycological herbarium at Ottawa labelled "*Chaetomium pannosum* Wallr., auf Carex, leg. P. Sydow, 1898", has also been found to be *C. elatum* Kze.

C. olivaceum Cke. & Ellis is considered to be a synonym of *C. globosum* Kze. by Chivers. Ellis and Everhart Fung. Columb. *512*, under *C. olivaceum*, was found by Chivers to consist in part of *C. globosum* Kze., of *C. elatum* Kze., and of *Chaetomidium fimeti* (Fckl.) Zopf. Our examination of this exsiccatum revealed only young perithecia and spores of what is likely *C. funicolum* Cke.

C. olivaceum Cke. & Ellis f. *chartarum* Roum., a synonym of *C. globosum* Kze., is listed by Chivers under *C. globosum* in Roum. Fung. Sel. Gall. *4930*. Our examination of Fung. Gall. *4930* yielded *C. elatum* Kze. and what appeared to be young perithecia of *C. cochliodes* Palliser.

In D. Sacc. Myc. Ital. *1475*, sub *C. pannosum* Wallr. we have found only *C. murorum* Cda. whereas Chivers found both *C. elatum* Kze. and *C. murorum* Cda.

In Roum. Fung. Sel. Gall. *325*, sub *C. atrum* Lk. (syn. *C. elatum* Kze.) only *Chaetomidium fimeti* (Fckl.) Zopf could be found, as also reported by Chivers.

In Roum. Fung. Sel. Gall. *2496*, sub *C. atrum* Lk. f. *Therryana* Roum. et Pat. we have found both *C. elatum* Kze. and *Chaetomidium fimeti* (Fckl.) Zopf. Chivers considers *C. atrum* f. *Therryana* to be a synonym of *Chaetomidium fimeti* and not of *C. elatum* on the basis of "a study of the original description and accompanying figures (Rev. Myc. 5 : 29) together with an examination of authentic specimens in Fung. Gall. No. *2496*".

In E. & E. Fung. Columb. XI, *1034*, we have found young perithecia and spores of *C. funicolum* Cke. only, whereas Chivers cites this specimen under *C. elatum* Kze. without further comment.

Chaetomium cuniculorum Fuckel Symb. Myc. p. 89. 1870.

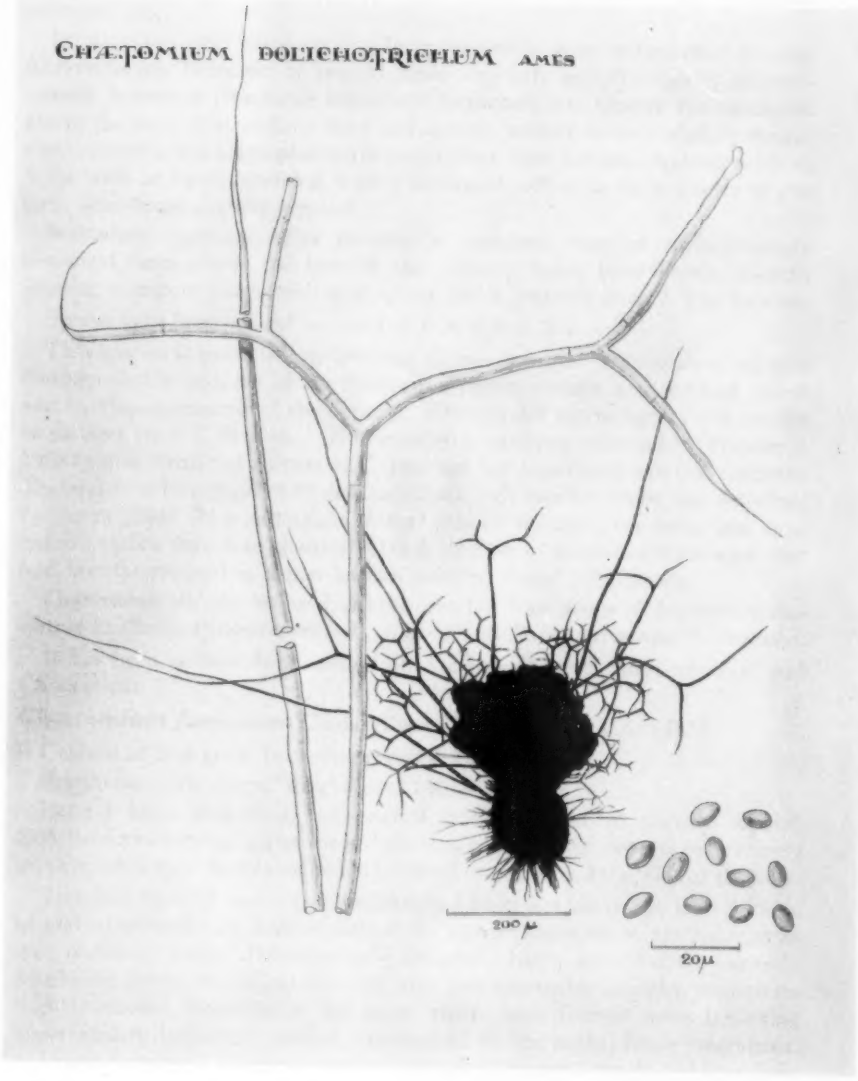
This species has not been isolated from seed nor has it been possible to examine any satisfactory specimens. A culture so-named received from Centraalbureau voor Schimmelcultures failed to fruit.

This species is described as having dichotomously branched terminal hairs but should be easily distinguishable by the large size of the perithecium, 370μ, stiff, stout hairs with anastomosing dichotomous branches, simple terminal hairs, and large, elliptical or spindle-shaped spores, 10–12 $\times$ 7–9μ. In these characters it would appear to most nearly approach *C. elatum*, which, however, has larger perithecia, and lemon-shaped, broader spores.

Chaetomium dolichotrichum Ames (Plate II) Mycologia, 37 : 145. 1945.

Culture at first white to gray becoming smoky olive with perithecial formation.

Perithecia olive to smoky-gray colored, globose to subglobose, 100–150μ in diameter, produced early, at the center of the culture.


CHÆTOMIUM DOLICHOTRICHUM AMES
200 μ
20μ

Lateral hairs few, relatively short, brown becoming lighter colored toward the tip, about 3–4μ wide at base, smooth to slightly roughened, regularly septate, tapering abruptly to a blunt round point or in some cases with long collapsed tip.

Primary terminal hairs varying from extremely long, unbranched to once dichotomously branched to several times regularly and divergently dichotomously branched (the more frequently branched, the shorter the extension above the mass of secondary hairs and spores), smooth or only slightly roughened or with a few prominent blunt projections, dark brown, regularly septate, 5.5μ wide at base; branches widely divergent, often at right angles to the axis, sometimes slightly reflexed.

Secondary terminal hairs forming a compact mass of dichotomously branched hairs about the base of the primary hairs, light brown colored, septate, minutely roughened, of irregular width, varying from 2.5 to 3μ wide.

Spores light brown, oval to ovoid, 6.0 × 4.0–5.5 μ.

This species is intermediate between *C. indicum* and *C. funicolum* but it is distinguishable because of its distinctive primary hairs as described above and by the appearance of the culture. Chivers did not recognize this species as distinct from *C. indicum*. He identified a specimen collected by Thaxter in 1908 from a Brazil nut culture as *C. indicum* but examination of this specimen discloses it to be typical of *C. dolichotrichum*. *C. dolichotrichum* was described by Ames (1945 (6)) and examination of both the type specimen and type culture shows that it is identical with a number of isolations from seed that had been segregated as a new species prior to Ames' publication.

Chaetomium dolichotrichum has been isolated from seeds of *Linum usitatissimum* L. (flax), *Pisum sativum* L. (peas), and *Raphanus sativus* L. (radish).

It has been isolated from seeds from Quebec, Ontario, Saskatchewan, and Connecticut.

Chaetomium funicolum Cooke (Plate III) Grev. 1 : 176. 1873.

Culture at first gray, becoming greenish.

Perithecia dark green, subglobose, 140–185μ wide.

Lateral hairs numerous, unbranched, long, straight to slightly curved, dark brown becoming lighter toward the long collapsed tip, septate to obscurely septate, smooth to finely roughened by blunt projections, 4–5μ wide at the base.

Terminal hairs of two types; unbranched hairs similar to the lateral hairs, at maturity projecting a short distance or almost obscured by the spore mass and branched hairs; dichotomously branched hairs, dark brown, coarsely roughened by blunt projections and with the internodes straight, sometimes slightly curved, branches at an acute angle, later formed hairs becoming less regularly branched, narrow, constricted at the septa, finely roughened, at length forming a closely branched network of slightly roughened branches; the whole forming a compact dark mass with the spores above the perithecium.

Spores ovoid, oval to elliptical, indistinctly umbonate to acute on the ends, colored, 5.0–6.5 × 4.5–5.0μ.

This is a variable species and one that may be easily confused with *C. indicum* on the one hand, and with *C. dolichotrichum* on the other. It may be distinguished from *C. indicum* by the presence of unbranched terminal hairs and the less regular and acute branching of the dichotomously branched terminal hairs. It differs from *C. dolichotrichum* in its straight, short projecting, unbranched terminal hairs and the stout, straight, roughened, acute branches of the branched terminal hairs.

Chaetomium funicolum has been isolated from seeds of *Allium Cepa* L. (onion), *Brassica oleracea L.* var. *capitata* L. (cabbage), *B. Rapa* L. (turnip), *Cucumus sativa* L. (cucumber), *Festuca elatior* L. (meadow fescue), *Glycine Max* Merr. (soybean), *Linum usitatissimum* L. (flax), *Lycopersicon esculentum* Mill. (tomato), *Pisum sativum* L. (peas), *Vicia villosa* Roth. (hairy vetch), and *Zea Mays* L. (corn).

It has been isolated from seeds from Quebec, Ontario, Manitoba, British Columbia, and Michigan in North America, and also from Denmark and Japan.

Exsiccati.—Sub *Chaetomium elatum* Kze.: E. & E. Fung. Columb. *1034*, we have found *C. funicolum* whereas Chivers lists this under *C. elatum*. Sub *C. olivaceum* Cke. & Ellis (syn. *C. globosum* Kze.): E. & E. Fung. Columb. *512*, we found only *C. funicolum*. Chivers states that this exsiccatum is a mixture of *C. globosum*, *C. elatum*, and *Chaetomidium fimeti*. Sub *C. setosum* E. & E. (syn. *C. funicolum* Cke.): E. & E. Fung. Columb. *1126*. The type of *C. setosum* E. & E. in N.A.F. 2d Ser. XXXV, *3423*, has been examined and although the perithecia are immature the specimen agrees with *C. funicolum*.

Chaetomium indicum Corda (Plate IV) Icon. Fung. IV, t. VIII, f. 104. 1840.

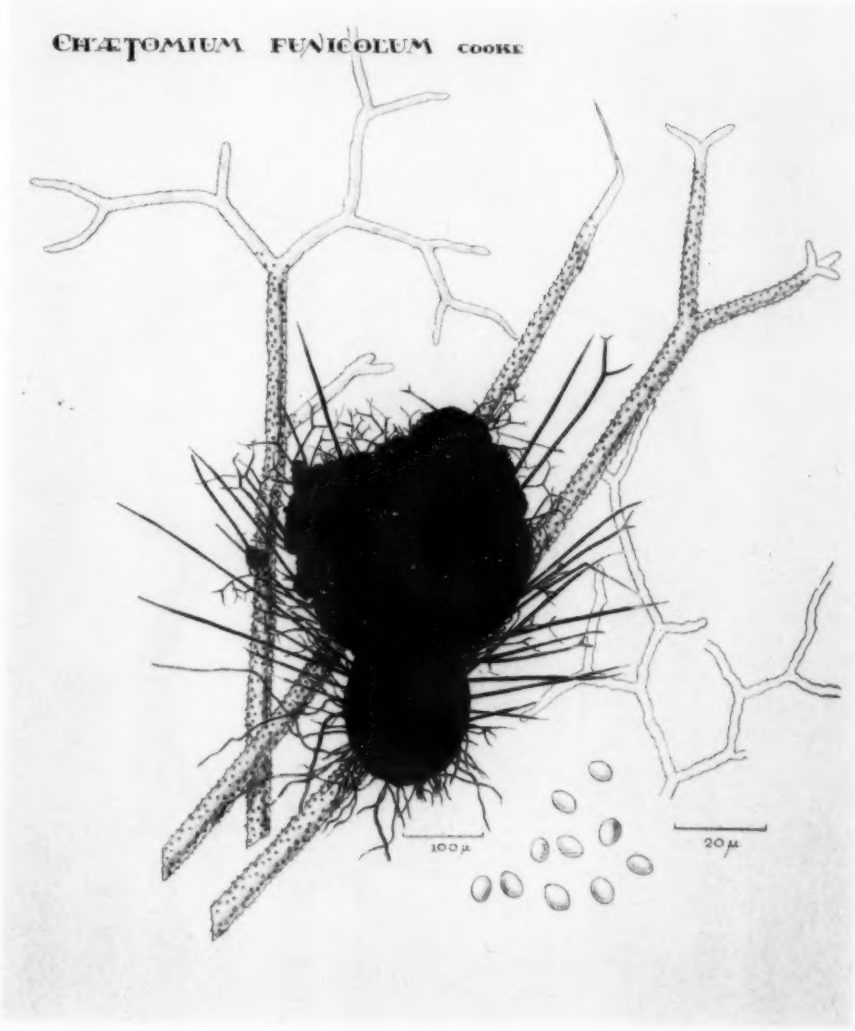
Culture variable in color and rate of growth, varying from gray, yellowish to green.

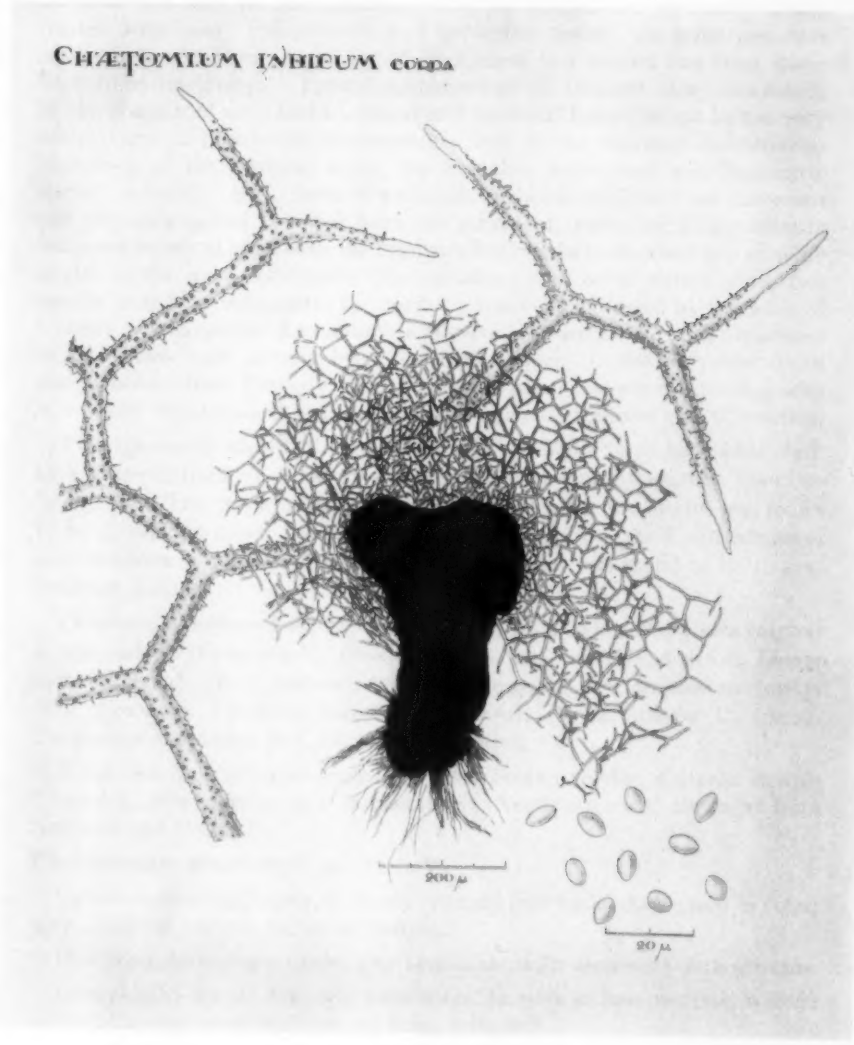
Perithecia olive-green, subglobose, 120–170–(200)μ wide.

Lateral hairs lacking or few, unbranched or few times dichotomously branched, straight or slightly curved upward, dark brown below becoming lightly colored above, tapering to a long, collapsed hyaline tip, regularly septate, smooth or very slightly roughened.

Terminal hairs: unbranched hairs lacking or few and obscured by the mass of branched hairs and spores; branched hairs several times dichotomously and regularly branched almost at right angles to the axis and slightly reflexed (sometimes slightly incurved) with the internodes of approximately equal length, the whole forming a regular network, dark brown, slightly roughened by rounded projections near the blunt tips, 5–6μ wide; later formed hairs narrow, branching acutely, uneven, roughened by numerous sharp projections.

Spores ovoid, oval to broadly oval to subglobose, sometimes flattened on one side, rounded on the ends or slightly umbonate at one or both ends, dark colored (5.0)–6.5–7.5 × (4.0)–4.5–5.5μ.


CHÆTOMIUM FUNICOLUM COOKE
100 μ
20 μ


CHÆTOMIUM FIMBRIATUM CORDA
200 μ
20 μ

The above description applies, in the main, to typical material of *C. indicum* but in many specimens intermediate characters between *C. indicum* and *C. funicolum* may be encountered. The two species are obviously closely related with many intermediate and borderline forms. In some instances assigning a specimen to one or other of these two species has been made with some misgivings. Typical specimens of *C. indicum* differ essentially in the absence of unbranched lateral and terminal hairs (except in the very early stages of perithecial development), and in the regularly dichotomous branching of the terminal hairs, the branches widespread and frequently slightly reflexed. In *C. funicolum* the unbranched lateral hairs are numerous and the unbranched terminal hairs are persistent, while the dichotomously branched terminal hairs have the branches less regularly disposed and at acute angles to the axis. Obviously the variations that occur within these two species have been responsible for much confusion as indicated by the work of Chivers. Two species that undoubtedly would formerly have been considered as *C. indicum* have already been described, namely, *C. dolichotrichum* Ames and *C. cancroideum* Tschudy. In the present paper two other related species have been distinguished and described as new, *C. reflexum* and *C. erectum*.

Two specimens identified by Chivers as *C. indicum* have been examined. One of these, from a laboratory culture at Cambridge, Mass., was found to be typical. The other, collected by R. Thaxter from a Brazil nut, was found to be *C. dolichotrichum* Ames. A culture received from the Centraalbureau voor Schimmelcultures and labelled *C. indicum* Cda. was found to be *C. cancroideum* Tschudy.

Chaetomium indicum has been isolated from the following seeds: *Beta vulgaris* L. var. *cicla* L. (Swiss chard), *Daucus carota* L. var. *sativa* DC. (carrot), *Linum usitatissimum* L. (flax), *Lolium perenne* L. (rye grass), *Lycopersicon esculentum* Mill. (tomato), *Phaseolus vulgaris* L. (beans), *Pisum sativum* L. (peas), *Taraxacum kok-saghyz* Rod. (Russian dandelion).

It has been isolated from seeds from Nova Scotia, Quebec, Ontario, British Columbia, New Jersey, and Minnesota in North America, and also from Scotland and Holland.

Chaetomium erectum n. sp. (Plate V)

Culture consisting largely of closely grouped perithecia, dark green in color, with a narrow white to yellowish margin.

Perithecia dark green, ovoid, 130–140μ wide, with numerous dark rhizoids.

Lateral hairs simple, few, relatively short, 4μ wide at base, septate, colored below becoming hyaline above, tip long, collapsed.

Terminal hairs: unbranched hairs lacking; branched hairs few times dichotomously branched, stout, 6.5μ wide, rigid, dark, smooth below, becoming hyaline and somewhat roughened above especially toward the short tip, internodes short, the hairs forming an erect, relatively short, stout cluster at the top of the perithecium.

Spores dark, unequally oval to elliptical, acute at both ends, 6.5–7.5 × 4.5–5.0μ.

Peritheciis atro-viridis, ovoideis, 130–140μ latis; rhizoideis numerosis, brunneis; pilis lateralibus paucis, simplicibus, septatis, basi 4μ diam., brunneis, apice hyalinis, collapsis; pilis terminalibus dichotome paululum ramosis, rigidis, atro-brunneis, basi 6.5μ diam. lenibus, ultimis ramis hyalinis asperulis, brevibus; ascosporis olivaceo-brunneis, inaequaliter ovoideis vel ellipticis, utrinque acutis, 6.5–7.5 × 4.5–5.0μ.

Hab.: *Petroselinum hortense* Hoffm.—semina germinantes.

Type specimen has been deposited in the herbarium at Ottawa as number DAOM 14205.

C. erectum has been isolated only once, from seed of parsley, from Milford, Conn., July 6, 1943. Culture 42-I-351A.

This species may be confused with the early stages of *C. indicum*, which, however, produces many times branched hairs that are less rigid and erect and with longer internodes, the branching nearly at right angles. It resembles *C. reflexum*, which also has relatively short, stout, branched terminal hairs but in *C. reflexum* the hairs are arcuate and the branches strongly reflexed or curved.

Chaetomium cancroideum Tschudy (Plate VI) Am. J. Botany, 24 : 478. 1937.

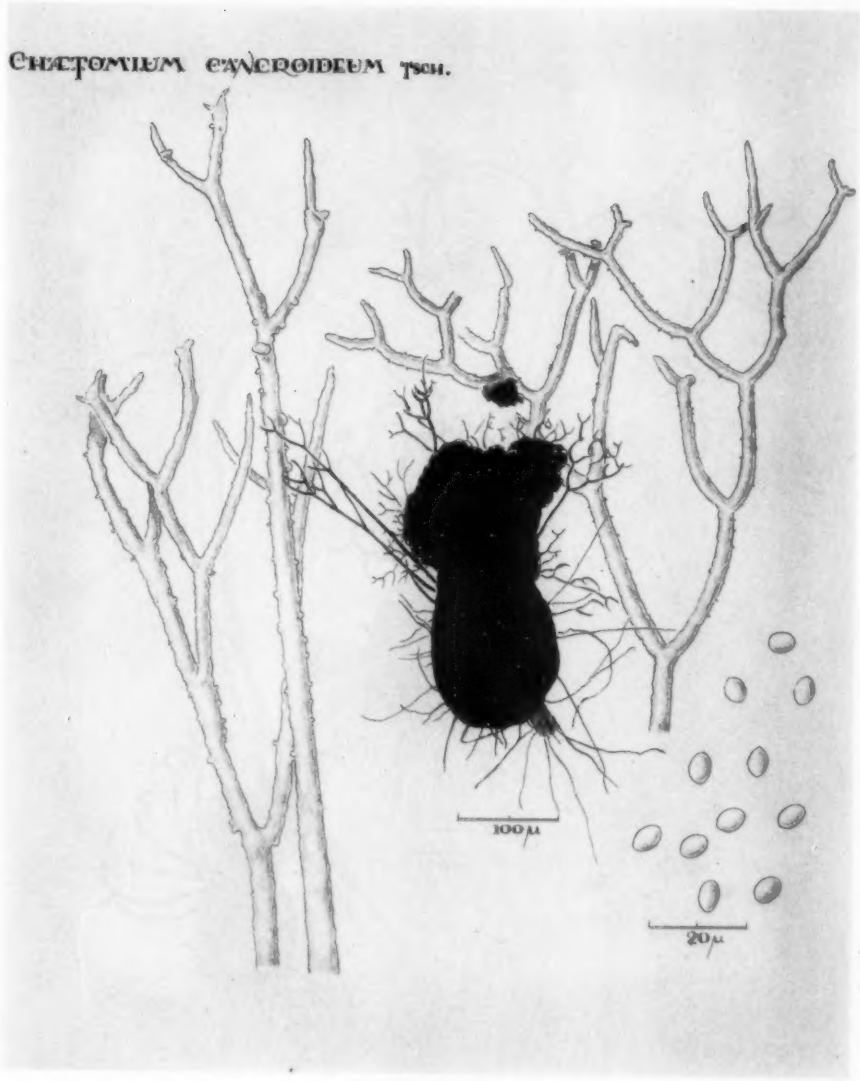
Although this species has not been isolated from seed it has been possible to examine three specimens, one in the Farlow Herbarium identified by L. M. Ames, 1944, and two cultures from the Centraalbureau voor Schimmelcultures, one of which was incorrectly labelled *C. indicum* Cda.

The original description as presented by Tschudy follows in part: ". . . . Perithecia small, subglobose, 180 × 160μ (105–200 × 101–175), attached to substratum by rhizoids . . . . Lateral hairs not prominent, mostly smooth, stiff, dark brown at base becoming lighter brown to hyaline at tip, rarely and obscurely septate; terminal hairs forming an extremely dense compact head, dichotomously branched in the upper half of the hair; branches very many; angles between branches narrow, acute, concave on the inner side and thus producing the characteristic overlapping or 'crab-claw' effect; occasionally inflated and constricted while the entire length is covered with spines and irregular projections; terminal perithecial spines medium long, brown to black in color, and usually inconspicuous and hidden by the profuse dichotomous setae . . . . . Spores when young greenish blue, with one to several refractive globules; when mature dark brown, lemon shaped, ends more often rounded than apiculate or umbonate; 5.1 × 3.3μ(4.4–5.8 × 3.2–4.5); . . . . .".

This species may be distinguished from *C. erectum* and *C. reflexum*, which also have small perithecia and dichotomously branched terminal hairs, by the fact that the terminal hairs are more graceful with numerous branches arising at acute angles and concave or incurved producing the so-called 'crab claw' effect.

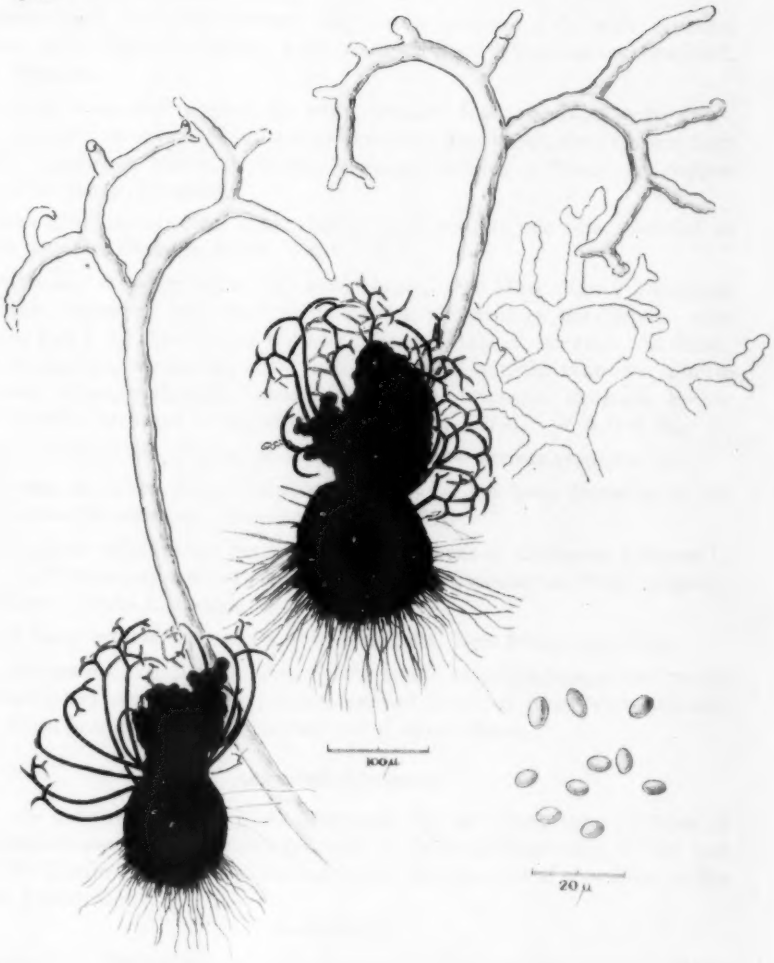
CHAETOMIUM ERECTUM

CHÆTOMIUM CANCROIDEUM Tsch.



CHÆTOMIUM REFLEXUM

TYPE



Chaetomium reflexum n. sp. (Plate VII)

Culture at first light gray in color, becoming dark gray with the formation of perithecia.

Perithecia black, ovoid to subglobose, small, 100–125μ wide, closely arranged forming an almost continuous layer, obscured by the dense mass of dark rhizoids and terminal hairs.

Lateral hairs few, unbranched, very short, narrow, 2.5μ wide at base, uneven, only slightly colored, with rounded tip, appearing as modified, short rhizoids.

Terminal hairs short, stout, 5μ wide, arcuate from the base, with short, stout, strongly recurved, dichotomous branches, tips blunt, dark brown, only slightly roughened above, obscurely septate, forming a dense, flat-topped mass above the perithecium.

Spores light olive-brown, oval, slightly flattened on one side, rounded to slightly acute on the ends, 5.0–6.5 × 4.0–4.5μ.

Peritheciis, atris, ovoideis vel subglobosis, 100–125μ diam.; rhizoideis numerosis, brunneis; pilis lateralibus paucis, simplicibus, brevissimis, subhyalinis, basi 2.5μ diam., apice obtusis; pilis terminalibus, brevibus, 5μ diam., arcuatis, dichotome ramosis, apice forte recurvatis, obtusis, brunneis, minute spiculosis, obscure septatis; ascosporis olivaceo-brunneis, ovoideis, leviter inaequilateris, utrinque rotundatis vel subacutis, 5.0–6.5 × 4.0–4.5μ.

Hab.: *Lycopersicon*, *Pisum*, *Hibiscus*, *Capsicum*—semina germinantes.

The type specimen, from *Capsicum annuum* L., has been deposited in the herbarium at Ottawa under number DAOM 14201.

Chaetomium reflexum has been isolated from seeds of *Capsicum annuum* L. (pepper), *Hibiscus esculentus* L. (okra), *Lycopersicon esculentum* Mill. (tomato), and *Pisum sativum L.* (peas).

It has been isolated from seeds from Manitoba, New Jersey, and Ohio.

C. reflexum may be distinguished by the small, closely arranged perithecia, the flat-topped mass of short, stout, curved terminal hairs with reflexed, short, blunt branches. Cf. *C. erectum* and *C. cancroideum*.

Acknowledgments

We are indebted to Mr. J. A. Stevenson for providing type cultures of *C. dolichotrichum*, *C. pachypodioides*, and *C. microcephalum;* and to the late Dr. D. H. Linder for his assistance during the examination of specimens in the Farlow Herbarium.

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STUDIES IN FOREST PATHOLOGY

VI. IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI[1]

By Mildred K. Nobles[2]

Abstract

A numerical key for the identification of cultures of 126 species of wood-rotting fungi, with accompanying descriptions of the cultural characters of each species, is presented. The list of species includes many of the fungi most frequently encountered in studies of decay in various hosts, the species having been chosen without restriction as to host or locality. The descriptions and key have been based on cultural characters, both macroscopic and microscopic, that can be demonstrated readily without the aid of elaborate equipment or methods. Thus, cultures were grown in Petri dishes on Difco malt agar and on malt agar to which gallic or tannic acid had been added. They were incubated in the dark at room temperature and examined at weekly intervals for six weeks. Host relationships and physiological and morphological characters proved to be of diagnostic value. The physiological characters used in the key include the pigmentation of the mycelial mat, color changes induced in the agar by the fungus, rate of growth, and effect on media containing gallic or tannic acid. Morphological characters used in diagnosis were types and septation of hyphae, occurrence of secondary spores – chlamydospores, conidia, oidia – and of special structures, such as cystidia and setae, and the formation of fruit bodies. The numerical key will permit the interpolation of additional species as they are described and their code numbers prepared.

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[1] *Manuscript received January 23, 1948.*

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Introduction

The peculiar difficulty attached to the identification of cultures of wood-rotting fungi lies in the fact that, although they belong to species that have already been classified on the basis of the morphological characters of their fruit bodies, the cultures exhibit no characters by which they may be assigned to genera or families. All identifications must go to the species directly. This means that keys to the species within a genus are of little aid in determining cultures from rots, and the use of this convenient generic grouping is denied the worker in this field. To meet an immediate need workers have prepared keys for the identification of the cultures isolated from a single host, for example, oak (Davidson, Campbell, and Vaughn (67) and Cartwright and Findlay (53)), black cherry (Davidson and Campbell (63)), balsam fir (Fritz (74)), and Sitka spruce (Baxter and Varner (26)); or on a group of host species, for example, softwoods in use in Great Britain (Cartwright and Findlay (54)) and hardwoods in Great Britain (Cartwright and Findlay (55)); or on a special habitat, for example, building timbers (Snell (138)) and railway ties (Walek-Czernecka (150)). In these keys, only slightly over 100 species are listed, which, in comparison with the number of species of wood-rotting fungi that may be encountered, is a small group. Consequently it may well happen that many fungi, when isolated and needing identification, cannot be found at all in any of the keys.

Furthermore, the diversity of methods adopted by the various authors and the different diagnostic characters used in their keys make it difficult to translate the data supplied by one author into terms that will permit comparison with data given by another author. Thus Fritz (74) grew cultures on potato dextrose slants at 22° C. in the dark; Cartwright and Findlay (53, 54, 55) used 2% malt agar slants in diffuse light at room temperature, and in the dark at temperatures of 20°, 25°, 30°, 35°, and 40° C., and on media containing gallic or tannic acids; Snell (138) used malt agar in Petri dishes at temperatures from 0° to 40° C.; and Baxter and Varner (26) grew cultures on 2% malt agar in Petri dishes at temperatures of 25°, 30°, and 35° C., and on wood blocks over a period of two years. For diagnostic characters, Baxter and Varner (26) relied on growth rates and macroscopic appearance of the cultures; Fritz (74) and Snell (138) used, in addition, microscopic characters; and Cartwright and Findlay (53, 54, 55) and Davidson, Campbell, and Vaughn (67) used, along with macroscopic and microscopic characters, the effect of the cultures on media containing gallic or tannic acid. Because of this lack of uniformity in methods and diagnostic characters, and the fact that the characters exhibited by the cultures are correlated with the conditions under which they are grown, it is necessary to follow each author's method in order to make use of his key. The difficulties to be met in identifying, for example, a culture from black cherry, one from balsam fir, and one from Sitka spruce, are immediately apparent.

The removal of these difficulties, at least in part, could be achieved by the adoption of a standard method acceptable to all those working on the cultural

characters of wood-rotting fungi, and the use of a key, such as that published by Davidson and his associates or the one used in the present paper, into which additional species, as they are described, could be incorporated. Under such a system it would be possible for each new worker to add to the information already accumulated, rather than, as so frequently happens now, to plan a new procedure and repeat studies on species whose cultural characters are known more or less completely from the work of other investigators.

Meanwhile the publication of an additional key has seemed advisable since it is more general in its application than those already available. It brings together under one system a large group of species, chosen without restriction as to host or locality, although all the species but one are known to occur in Canada. The key includes many of the species most frequently encountered in decay studies on various hosts and so may be considered a basic list. It is planned that, as additional species are examined in this Laboratory, their descriptions and key patterns will be published in conformity with the present publication. In this way it is hoped to establish a comprehensive key for the identification of cultures of the wood-decaying fungi likely to be encountered in Canada.

Review of Literature

Much of the pertinent literature on cultures of wood-rotting fungi has been contributed by investigators who have studied cultures and sought means of identifying them for the practical purpose of determining the causes of decay in a given host or restricted habitat. Thus Cartwright and Findlay, from their work on the rots of English oak (53), hardwoods (55), and softwoods in use in Great Britain (54), contributed descriptions of the cultural characters of some 50 species of fungi. These descriptions are now available in the informative book, *Decay of Timbers and Its Prevention*, recently published by these authors (56). Davidson, Campbell, and Vaughn (67) described the cultures of 47 species causing decay in living oaks in the Eastern United States, and Davidson and Campbell (63) similarly described an additional nine species that cause decay in black cherry. Fritz (74) gave detailed descriptions of 18 species destructive to balsam fir and Snell (138), as a result of his investigations on the fungi causing decay in mill timbers, described five species in culture. Walek-Czernecka (150) published descriptions of the cultures of 21 species isolated from decays in railway ties in Poland, and Robak (134) gave comprehensive descriptions of six species important in the decay of coniferous wood in Norway.

Other investigators have studied the biology of a single species intensively and have published detailed information on its cultural characters, as, for example, Mounce (109) on *Fomes pinicola*, and Hilborn (83) on *F. fomentarius*. The variability encountered among several isolates of one species was the subject of studies by Hopp (87) and Verrall (149)—both of whom studied *Fomes igniarius*—and by Childs (57), working with *Polyporus Schweinitzii*, and Christensen (58), with *Polyporus circinatus*. Campbell (40) described the cultural characters of the species of *Fomes* and presented a key for their

identification. In his series of papers on resupinate polypores, Baxter (9 to 24) included cultural data for many species together with diagnostic keys based on cultural characters.

Much information on the physiology of wood-rotting fungi occurs incidentally in general accounts of various species, but several papers deal exclusively with physiologic reactions. Humphrey and Siggers (92) published data on the temperature relations of many species, and Snell, Hutchinson, and Newton (140) used temperature relations as a means of differentiating between the similar species, *Fomes roseus* and *Trametes subrosea*. Following a method originated by Bavendamm (5), Davidson, Campbell, and Blaisdell (64) tested the action on media containing tannic or gallic acid of about two hundred species of wood-inhabiting fungi. Of the 210 species, 36 produced no diffusion zone on either medium, 7 were inconsistent, while 166 produced diffusion zones. Of the 36 fungi that were consistently negative 30, or 83%, are associated with brown carbonizing rots; of 166 that were consistently positive 151, or 96%, are associated with white rots. Of the seven species giving inconsistent but mainly negative results six are definitely brown rot fungi while *Stereum subpileatum* is associated with a white pocket rot with darkening of the surrounding wood. They conclude "Thus Bavendamm's generalization, that brown rot fungi are negative when tested for oxidases by the use of gallic and tannic acids and that white rot fungi give positive reactions with the same media is essentially correct". Haas and Hill (78) state that the production of the brown diffusion zones is due to oxidation of the tannic or gallic acid. This reaction has proved to be of the utmost value as a diagnostic character.

The inhibitory action of certain contaminants on the growth of wood-decaying fungi in culture has been observed frequently. Overholts (123) recorded the antagonistic effect of a strain of *Penicillium notatum* on 29 species of fungi, including 22 that produce wood rots, and suggested the utilization of this phenomenon in identifying unknown cultures.

Most of the voluminous literature on interfertility phenomena in the Hymenomycetes is not relevant to a discussion of the identification of wood-rotting fungi, but one fact has emerged from it that has proved applicable. It has been demonstrated that, in heterothallic species, every monosporous mycelium obtained from one fruit body of a given species will pair with every monosporous mycelium from another fruit body of the same species from a different source so as to produce mycelium bearing clamp connections. This complete fertility is accepted as proof that the fruit bodies belong to the same species. By using this technique Mounce and Macrae (114) proved that the cultures derived from fruit bodies identified as *Fomes roseus* were interfertile, as were those isolated from fruit bodies identified as *F. subroseus*, but that no such interfertility occurred when pairings were made between isolates of *F. roseus* and *F. subroseus*. Thus additional evidence was obtained in support of the validity of the two species. Nobles (117) employed the same method to show that numerous cultures isolated from decays in coniferous wood were identical with a culture derived from a fruit body, described as *Poria microspora*

Overholts, but were distinct from cultures of *Trametes serialis*, which had formerly been considered the cause of the decay. This technique has practical applications in identification of cultures, since it may be applied to corroborate the identification of isolates that fruit in culture and from which monosporous cultures can be obtained.

Additional references that contain information on the cultural characters of individual species are cited under the appropriate species. The considerable volume of literature, especially that of recent publication, on the cultural characters of wood-decaying fungi and the identification of these fungi on the basis of their cultural characters, indicates the importance of this work.

Cultures

The cultures in the collection of wood-inhabiting fungi in the Division of Botany and Plant Pathology, Department of Agriculture, Ottawa, were the basis of the descriptions given in the present paper. This collection, established in 1924, was enlarged during the succeeding years by Dr. Irene Mounce and her associates. By the end of 1946 it contained 1265 named cultures, representing 340 species in 62 genera. In general, the aim has been to insure the authenticity of the cultures by isolating them from fruit bodies properly identified and deposited in the Mycological Herbarium, Department of Agriculture, Ottawa. However, some isolates received from contributors lack accompanying specimens, and others were obtained from rots not associated with fruit bodies. Most species are represented by a number of isolates, preferably from different hosts and geographic localities. It has been the practice to obtain cultures from the United States, Europe, and Asia, whenever possible, so that for many species cultures from widely separated localities are available for comparison. For a number of species there are, in addition, isolates from both fruit bodies and associated rots. The collection includes, therefore, not only cultures of a large number of species but also a sufficient number of isolates within the species to permit study and comparison. With few exceptions the cultures have remained in good condition, early isolates showing little deterioration during the long period they have been in culture.

Methods

To facilitate its use by other workers, the descriptions and key have been based on cultural characters, both macroscopic and microscopic, that can be demonstrated readily without the aid of elaborate equipment or methods. The descriptions include only those characters shown by the cultures when grown on malt agar and malt agar containing gallic or tannic acids, prepared according to the following formulae.

MALT AGAR

Difco powdered malt	12.5 gm.
Difco Bacto-agar	20.0 gm.
Distilled water	1000.0 cc.

The malt is added to the agar dissolved in water, filtered through several layers of cheesecloth, and sterilized for 20 min. at 15 lb. pressure.

GALLIC (OR TANNIC) ACID AGAR

Difco powdered malt	15.0 gm.
Difco Bacto-agar	20.0 gm.
Distilled water	1000.0 cc.
Gallic (or tannic) acid	5.0 gm.

This medium is prepared according to the method described by Davidson, Campbell, and Blaisdell (64), the agar and malt being added to 850 cc. of water, the remaining 150 cc. of water being placed in a separate flask. The contents of both flasks are sterilized for 20 min. at 15 lb. pressure. While the sterilized water is still hot, the gallic (or tannic) acid is dissolved in it, and this solution is added to the slightly cooled malt agar and thoroughly mixed with it before being poured directly into sterile Petri dishes.

Each isolate to be studied is grown on malt agar in a Petri dish for one week. From this actively growing culture a cube, two to three mm. square, is transferred to the edge of each of five 10 cm. Petri dishes containing about 30 cc. of malt agar. The cultures are incubated in the dark at room temperature, being brought into the light only for examination. They are examined and described at weekly intervals for six weeks, one being removed for photographing at the end of two weeks, four weeks, and six weeks. The Petri dishes containing gallic and tannic acid agars are inoculated in the center with cubes four to five mm. square, taken from four- to six-weeks-old cultures. The cultures on gallic or tannic acid media are examined and discarded at the end of one week, except in those cases where the effect on the medium is weak or difficult to determine.

The records for each isolate include data on the rate of growth, form, and character of the advancing zone, color and topography of the mat, the presence or absence of fruit bodies, the effect of the growth of the fungus on the color of the agar ("Reverse"), the odor, and the reaction on media containing gallic and tannic acids. In addition, the records contain descriptions, accompanied by *camera lucida* drawings, of the microscopic characters of the isolate based on the examination at suitable intervals of preparations from the advancing zone, aerial mycelium, and submerged mycelium. Preparations for microscopic examination are mounted in a 7% aqueous solution of potassium hydroxide and stained in an aqueous solution of phloxine.

In the hope that the description may allow for all or most of the variations that may be observed in cultures of the species and at the same time exclude other species, an attempt has been made to make the description cover the range of characters encountered in the several isolates, rather than to describe one typical isolate. The cultures on which the description for each species is based are listed under their numbers in the Mycological Herbarium, Department of Agriculture, Ottawa, along with host and locality in which the collection was made.

In the descriptions, the rate of growth is given in terms of the number of weeks required by the fungus to cover the agar in the Petri dish from the inoculum at the periphery of the dish. Those species that grow so slowly that the agar is not covered in six weeks are treated in one group under rate of growth. It appears that this system of describing growth rates will give sufficient range to include the variations in rate of growth that may be encountered when many isolates are grown at laboratory temperatures, which may vary considerably from time to time.

Throughout the study colors have been described according to Ridgway's (131) *Color Standards and Color Nomenclature*, but it is proposed to adopt the *Munsell Book of Color* (116) for future work. In the descriptions, the Munsell color equivalents are given in parentheses following the Ridgway names. These Munsell notations are considered to represent reasonably accurately the chips in the volume of Ridgway used. Complete accuracy of correlation with chips in other copies of Ridgway is impossible since the original colors are subject to change and cannot be reproduced satisfactorily. Free use has been made of Dr. D. H. Hamly's list of equivalents in the two systems, additional equivalents have been supplied by Mrs. B. R. Bellamy of the Munsell Color Company, Baltimore, and all notations have been checked by Dr. Hamly and Mr. W. I. Illman at the Department of Botany, University of Toronto. If the *Munsell Book of Color* is to replace Ridgway's *Color Standards and Color Nomenclature* in describing colors in the biological sciences, it would appear helpful to include both systems in descriptions during the transition period.

In describing the topography and texture of the mats, the terms used are largely those first employed by Long and Harsch (98), together with some introduced by Campbell (42). These terms, with their authors' original definitions, are included in the list below, the letters "L. and H." indicating that the definition was taken from Long and Harsch's paper and the letter "C.", from Campbell's paper. Microscopic structures in the cultures are usually identical with or similar to those present in the fruit bodies. Consequently the same descriptive terms are applicable to both. An attempt has been made to define these terms in the sense in which they are used in the present paper, but the definitions will probably apply equally well in broader usage.

TERMS USED IN DESCRIBING ADVANCING ZONE:

Even.—Margin a smooth line, without indentations.

Bayed.—Margin indented, scalloped.

Submerged.—Mycelium growing through the agar, below its surface.

Appressed.—"Mycelium which is prostrate on the surface of the agar. This with many fungi is the first stage in the aerial growth of the mycelium. Later this appressed mycelium may give place to other forms" (L. and H.).

Raised.—"Forming a mound on agar as opposed to appressed" (C.).

TERMS USED IN DESCRIBING TEXTURE OF MAT:

Chamoislike.—Smooth, with the texture of fine chamois.

Cottony.—"Erect, rather long (3 to 5 mm.) mycelium spreading in all directions" (L. and H.).

Crustose.—Forming a crust, usually dark in color.

Downy.—"Short, fine hairs, loosely scattered over the surface of the mycelium, giving it a downy appearance" (L. and H.).

Farinaceous.—Having a mealy surface, powdery.

Felty.—"Matted with intertwined hairs, resembling felt" (L. and H.).

Floccose.—"Scattered patches of short mycelium" (L. and H.).

Lacunose.—Covered with pits or depressions.

Plumose.—"Tufts of mycelium with a central axis from which short hyphae radiate" (L. and H.).

Plushlike.—Similar to velvety, but with a thicker 'pile'.

Silky.—"Long parallel threads of mycelium, more or less prostrate, like combed silk" (L. and H.).

Subfelty.—"A thin layer of mycelium consisting of short intertwined hairs" (L. and H.).

Velvety.—"Layer of mycelium with distinct, dense, straight, short hairs like pile of velvet" (L. and H.).

Woolly.—"A dense mass of mycelium consisting of long, tortuous, matted hairs. Cottony and woolly may both later become felty by the long hairs becoming matted and prostrate" (L. and H.).

TERMS USED IN DESCRIBING MICROSCOPIC CHARACTERS:

Bulbil.—Small compact mass of hyphae, apparently formed by one or more branches coiling tightly around a parent hypha, as in *Fomes nigrolimitatus*. Listed in the key as "3" under special structures (Pl. IV, Fig. 29).

Contorted incrusted hyphae.—Hyphal ends, usually with short irregular branches, covered with crystalline material, as in *Polyporus albellus* (Pl. VIII, Fig. 20) and *P. semipileatus* (Pl. XIV, Fig. 7). Listed in the key as "0" under special structures.

Cuticular cells.—Swollen cells, at first hyaline, with contents staining in phloxine, then empty, the walls remaining colorless, as in *Ganoderma applanatum* (Pl. VI, Fig. 4), or becoming brown, as in *Fomes igniarius* (Pl. IV, Fig. 19). Listed in the key as "5" under special structures.

Cystidia.—Hyaline structures, produced on aerial mycelium, resembling the sterile organs occurring with the basidia in the hymenium of many species of Hymenomycetes, seen in cultures of *Polyporus abietinus* (Pl. VIII, Fig. 14), *Echinodontium tinctorium* (Pl. II, Fig. 30), and others. Listed in the key as "1" under special structures.

Dendritic.—Treelike branching exhibited by some hyphae in *Polyporus anceps* (Pl. VIII, Fig. 26).

Fiber hyphae.—Hyphae with thick refractive walls, hyaline or brown, and lumina narrow or apparently lacking, observed in many species, as for example, *Ganoderma applanatum* (Pl. VI, Fig. 2) and *Lenzites trabea* (Pl. VI, Fig. 45).

Helicoid hyphae.—Hyphae with ends in a coiled or spiral form, as in *Fomes fulvus* (Pl. IV, Fig. 14).

Hyphae with numerous interlocking projections.—Hyphae forming a pseudoparenchymatous layer, as seen in cultures of *Polyporus dryophilus* var. *vulpinus* (Pl. X, Fig. 33). Listed in the key as "6" under special structures.

Lactiferous cells.—Large cells, up to 30μ in diameter, with deeply staining contents, conspicuous in mounts from *Polyporus resinosus* (Pl. XII, Fig. 49). Listed in the key as "8" under special structures.

Nodose-septate.—With clamp connections at the septa.

Secondary spores.—Spores produced by species of Hymenomycetes, but not borne on basidia,—

> *Chlamydospores*, secondary spores with walls more or less thickened, hyaline or colored, borne at the end of (terminal) or within (intercalary) ordinary vegetative hyphae, as in *Daedalea quercina* (Pl. II, Fig. 21).
>
> *Conidia*, secondary spores with thin walls, borne terminally on specialized structures, the conidiophores, as in *Fomes annosus* (Pl. II, Fig. 34), and *Polyporus sulphureus* (Pl. XIV, Figs. 13, 14).
>
> *Oidia*, secondary spores with thin walls, produced by the fragmentation of ordinary vegetative hyphae, as in *Collybia velutipes* (Pl. II, Fig. 8).

Rigid hyphae.—Hyphae with right-angled branching and refractive walls, conspicuous in mounts from *Poria carbonica* (Pl. XVI, Fig. 9). Listed in the key as "4" under special structures.

Setae.—Yellow or brown, thick-walled structures, borne on aerial mycelium, resembling the setae present in the fruit bodies of many species of Hymenomycetes, seen in cultures of *Fomes Pini* (Pl. IV, Fig. 38), *Polyporus gilvus* (Pl. XII, Fig. 5), and others. Listed in the key as "2" under special structures.

Setal hyphae.—Dark brown, thick-walled hyphae with setalike ends, occurring in *Poria Weirii* (Pl. XVI, Fig. 45) and in other species. Listed in the key as "2" under special structures.

Staghorn hyphae.—Hyphae with clumps of repeatedly branched hyphae, the branching usually dichotomous, observed in several species of *Ganoderma* (Pl. VI, Figs. 3, 7, 11, and 19) and elsewhere.

In the use of media containing gallic and tannic acids, the methods of studying and recording the reactions have been those of Davidson, Campbell, and Blaisdell (64), the following terms descriptive of the strength of the reactions being substituted for the symbols used by these authors.

Lacking.—"−, Negative, no brown discoloration of the agar under or about the mat."

Very weak.—"+, Diffusion zone light to dark brown, formed under inoculum at center of mat and visible only from under side of dish. In case no growth takes place, a faint brown discoloration under the inoculum."

Weak.—"++, Diffusion zone light to dark brown, formed under most of mat but not extending to margin. Visible from under side only."

Moderately strong.—"+++, Diffusion zone light to dark brown, extending a short distance beyond the margin of the mat and visible from the upper side."

Strong.—"++++, Diffusion zone dark brown, opaque, extending considerably beyond margin of fungus mat."

Very strong.—"+++++, Diffusion zone very intense, dark brown, opaque, forming a wide corona about mat. Usually such intense reactions occur with species giving no growth on the medium, and are most common on gallic acid medium."

Accompanying the description of each species are brief notes on the type of rot produced by the species, and its host range. This information has been obtained from the literature, especially from Boyce (35), Lowe (99, 100), Overholts (119, 120), and Shope (136), as well as from records in the Department of Agriculture, Ottawa, Mycological Herbarium, and personal observation. The lists of references to publications containing data on the cultural characters of the species described are not claimed to be complete, but they indicate the literature that has been readily available.

Key for the Identification of Cultures of Wood-rotting Fungi

The key provides for the identification of the cultures of 126 species of wood-rotting fungi, the majority of which belong to the Polyporaceae, with fewer representatives from the Agaricaceae, Thelephoraceae, and Hydnaceae. The list includes many of the species commonly encountered in decay studies on various hosts and may be considered as a basic list.

As will be observed, the key consists of a series of "key patterns" (Davidson, Campbell, and Vaughn (67)) arranged in ascending numerical order. Each column of digits in the key refers to a specific diagnostic character. The first digit refers to the host, the second to the color of the mycelial mat, the third to the reaction on media containing gallic and tannic acids, and so on. The actual digit in each column has a precise meaning. Thus, in the first column, "1" indicates that the host is a broad-leaved tree, "2" that it is a coniferous tree; in the second column, "1" indicates that the mycelial mat remains white or pale for six weeks, "2" that it becomes yellow or brown, at least when mature; in the fourth column, "1" means that clamp connections are regularly present in all parts of the mat, "2" that all hyphae have simple septa, "3" that hyphae of the advancing zone have simple septa while those of the older part of the mat have clamp connections, "4" that multiple clamp connections are present.

The following list indicates the meaning attached to each digit as it is used in each of the columns.

First column.—Host.

1. Occurring on broad-leaved trees.
2. Occurring on coniferous trees.

Second column.—Color of mycelial mat.

1. Mat remaining white or pale yellow or pale pink for six weeks.
2. Mat yellow or brown, at least when mature.

Third column.—Reaction on media containing gallic and tannic acid agars.

1. Diffusion zone present.
2. Diffusion zones lacking.

Fourth column.—Septation of hyphae.

1. Clamp connections regularly present on all parts of mat, although fiber hyphae lacking them may occur.
2. Simple septa on all hyphae.
3. Hyphae of advancing zone with simple septa, those of older part of mat with clamp connections.
4. Multiple clamp connections present, at least in the advancing zone.

Fifth column.—Special structures.

0 to 8. Special structures present.

- 0. Contorted incrusted hyphae.
- 1. Cystidia or gloeocystidia.
- 2. Setae or setal hyphae.
- 3. Bulbils.
- 4. Rigid hyphae with right angled branches.
- 5. Cuticular cells, forming pseudoparenchymatous layer.
- 6. Hyphae with numerous interlocking projections.
- 7. Swellings on hyphae.
- 8. Lactiferous cells.

9. No special structures.

Sixth column.—Chlamydospores.

1. Chlamydospores present.
2. Chlamydospores lacking.

Seventh column.—Conidia.

1. Conidia present.
2. Conidia lacking.

Eighth column.—Oidia.

1. Oidia present.
2. Oidia lacking.

Ninth column.—Rate of growth.

1. Rate of growth rapid, plates covered in one to two weeks.
2. Rate of growth moderately rapid, plates covered in three to four weeks.
3. Rate of growth slow, plates covered in five to six weeks.
4. Rate of growth very slow, plates not covered in six weeks.

Tenth column.—Fruiting.

1. Fruiting before the end of six weeks.
2. No fruiting.

Eleventh column.—Effect on agar.

1. Reverse brown, at least in part, before the end of six weeks.
2. Reverse unchanged, or not darker than honey yellow in six weeks.
3. Reverse bleached, at least in part, before the end of six weeks.

For a given species the key pattern is prepared by considering the diagnostic characters of the species in the order in which they occur in the key and choosing the proper digit for each column. Thus *Polyporus anceps* occurs on coniferous trees (2); its mat remains white (1); it has positive reactions on media containing gallic and tannic acid (1); it has clamp connections (1), no special structures (9), no chlamydospores (2), no conidia (2), no oidia (2); its growth rate is rapid (1); it fruits (1); and the reverse remains unchanged (2). The key pattern is, therefore,

2 1 1 1 9 2 2 2 1 1 2 .

Under the method employed, most of the species vary in one or more characters. For example, *Fomes pinicola* may occur on both broad-leaved and coniferous trees (1,2), may or may not produce chlamydospores (1,2), and may grow moderately rapidly or slowly (2,3), and its key pattern, to show these possible variations must be

(1,2) 1 2 1 9 (1,2) 2 2 (2,3) 2 2 .

In the key, those species that do not vary in any of the diagnostic characters occur only once, those that have one variable character occur twice, those with two variable characters four times, and those with three variable characters, eight times, since provision must be made for all possible combinations of the variable characters. When the key patterns for all the species are arranged in numerical order, it becomes apparent that several groups of species have identical key patterns. Within such groups, separation must be made on the the basis of characters impossible to include in a numerical key, such as texture and topography of mat, color, host specificity, and so on. Consequently it has been necessary to insert descriptive keys. Frequently the notes accompanying the individual descriptions will aid in separating two species having identical key patterns, and in such cases descriptive keys have been omitted.

When an unknown culture is being identified, its cultural characters must be determined under the conditions prescribed, and its key patterns prepared and matched with those in the key. Comparison must then be made with the descriptions of species with identical key patterns, and where possible, with living cultures.

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	1	1	1	0	1	2	2	2	1	2	*Polyporus albellus*
1	1	1	1	0	1	2	2	2	2	2	*Polyporus albellus*
1	1	1	1	0	2	2	2	4	2	1	*Polyporus semipileatus*
1	1	1	1	0	2	2	2	4	2	2	*Polyporus semipileatus*
1	1	1	1	1	2	2	2	2	1	2	*Polyporus pargamenus*
1	1	1	1	1	2	2	2	2	2	2	*Polyporus abietinus* *Polyporus pargamenus*
1	1	1	1	5	1	2	2	1	2	3	*Ganoderma lucidum*
1	1	1	1	5	1	2	2	2	1	2	*Fomes fraxineus*
1	1	1	1	5	1	2	2	2	2	2	*Fomes fraxineus*
1	1	1	1	5	2	2	1	2	2	1	*Polyporus graveolens*
1	1	1	1	5	2	2	1	2	2	2	*Polyporus graveolens*
1	1	1	1	5	2	2	2	2	2	2	*Ganoderma applanatum*
1	1	1	1	5	2	2	2	4	2	2	*Ganoderma applanatum*
1	1	1	1	6	2	2	1	4	2	2	*Polyporus squamosus*
1	1	1	1	6	2	2	2	2	2	2	*Collybia radicata*
1	1	1	1	9	1	2	2	1	1	2	Chlamydospores rare; basidiospores cylindric, 5.4–7.5 × 2.2–2.7μ *Polyporus hirsutus*
											Chlamydospores numerous; basidiospores ovoid, truncate, 6.0–9.0 × 4.5–6.0μ; always on *Quercus* spp. *Polyporus compactus*
											Chlamydospores numerous; basidiospores rare, broadly ovoid, 5.4 × 3.6μ *Polyporus distortus*
1	1	1	1	9	1	2	2	1	2	2	*Polyporus hirsutus* *Polyporus zonatus*
1	1	1	1	9	1	2	2	1	2	3	Chlamydospores numerous, 7.5–15.0 × 4.5–6.0μ; odor very sweet *Trametes suaveolens*
											Chlamydospores rare to numerous, 6.0–12.0 × 4.5–7.5μ; no odor *Polyporus zonatus*
											Chlamydospores rare to numerous, 4.5–7.5 × 2.2–4.5μ; strong 'fishy' odor *Polyporus versicolor*
1	1	1	1	9	1	2	2	2	1	1	*Polyporus frondosus*
1	1	1	1	9	1	2	2	2	1	2	Mat felty, 'corroded', fruiting in compact pored areas; chlamydospores numerous, with thick sculptured walls, 10.5–16.5 × 7.5–12.0μ; basidiospores subglobose or broadly ovoid, 4.5–6.0μ *Fomes fraxineus*
											Mat felty to chamoislike, frequently fruiting along radii; chlamydospores thin-walled, 9.0–18.0 × 6.0–9.0μ; basidiospores ovoid, 6.0–7.5 × 4.5–6.0μ *Fomes fraxinophilus*
											Mat cottony-woolly, with scattered balls of soft cottony mycelium, later waxy and pored; chlamydospores numerous, thin-walled, 6.0–12.0 × 4.5–7.0μ; basidiospores hyaline, allantoid, 3.0–4.0 × 1.5μ *Polyporus albellus*
											Mat felty to chamoislike, with overgrowth of tufted mycelium, where fruiting occurs; chlamydospores numerous, thick-walled, 8.0–13.5 × 6.0–9.0μ; basidiospores ovoid, truncate, 6.0–9.0 × 4.5–6.0μ *Polyporus compactus*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	1	1	1	9	1	2	2	2	1	2	Mat pink, downy to cottony-floccose; chlamydospores rare, thin-walled, 10.5–24.0 × 6.0–7.5μ; basidiospores cylindric, curved, 6.0–8.0 × 1.5–2.0μ ---------- *Fomes subroseus*
											Mat woolly-felty, fruiting in compact areas; strong odor of carbide; chlamydospores few to abundant, walls slightly thickened, 10.5–22.0 × 9.0–16.5μ; basidiospores ellipsoid to ovoid, 5.0–6.5 × 3.5–4.5μ ---------- *Polyporus frondosus*
											Mat cottony, translucent except for dots or larger areas opaque, subfelty to waxy, minutely pored; chlamydospores numerous, with walls somewhat thickened, 7.5–13.5 × 4.5–9.0μ; basidiospores ellipsoid to oblong, 3.6–4.5 × 2.7μ ---------- *Polyporus fumosus*
											Mat woolly-felty to plasterlike, with large compact lumps that may become pored; chlamydospores rare or apparently lacking, thin-walled, 10.5–16.5 × 4.5–7.0μ; basidiospores cylindric, 5.4–7.2 × 2.2–2.7μ ---------- *Polyporus hirsutus*
											Mat raised, woolly, with typical fruit bodies on surface, distorted ones growing between halves of Petri dish; chlamydospores with walls slightly thickened, 6.0–15.0 × 4.5–7.5μ; basidiospores cylindric, 3.0–4.0 × 1.5μ ---------- *Schizophyllum commune*
1	1	1	1	9	1	2	2	2	2	1	---------- *Polyporus frondosus*
1	1	1	1	9	1	2	2	2	2	2	Mat felty, 'corroded'; chlamydospores numerous, with thick sculptured walls, 10.5–16.5 × 7.5–12.0μ ---------- *Fomes fraxineus*
											Mat fine woolly, with few scattered compact lumps; chlamydospores numerous, thin-walled, 7.5–12.0 × 6.0–9.0μ ---------- *Lentinus tigrinus*
											Mat cottony-woolly with scattered balls of soft cottony mycelium; chlamydospores numerous, thin-walled, 6.0–12.0 × 4.5–7.0μ ---- *Polyporus albellus*
											Mat woolly-felty; chlamydospores few to abundant, walls slightly thickened, 10.5–22.0 × 9.0–16.5μ ---------- *Polyporus frondosus*
											Mat cottony, translucent except for scattered dots or larger areas that are opaque and subfelty; chlamydospores numerous, with walls somewhat thickened, 7.5–13.5 × 4.5–9.0μ ---- *Polyporus fumosus*
											Mat woolly-felty to plasterlike, with large compact lumps; chlamydospores rare or apparently lacking, thin-walled, 10.5–16.5 × 4.5–7.0μ ---------- *Polyporus hirsutus*
											Mat raised, woolly; chlamydospores with walls slightly thickened, 6.0–15.0 × 4.5–7.5μ ---------- *Schizophyllum commune*
1	1	1	1	9	1	2	2	2	2	3	---------- *Polyporus versicolor* *Trametes suaveolens*
1	1	1	1	9	1	2	2	3	1	1	---------- *Polyporus frondosus*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	1	1	1	9	1	2	2	3	1	2	---------- *Polyporus frondosus* *Polyporus obtusus*
1	1	1	1	9	1	2	2	3	2	1	---------- *Polyporus frondosus*
1	1	1	1	9	1	2	2	3	2	2	Chlamydospores few to abundant, with walls slightly thickened, 10.5–22.0 × 9.0–16.5μ; strong odor of carbide---------- *Polyporus frondosus*
											Chlamydospores numerous, thin-walled, 6.0–13.5 × 6.0–9.0μ; odor strong, fragrant ---------- *Polyporus obtusus*
											Chlamydospores numerous, usually rough-walled, 7.5–21.0 × 4.5–12.0μ; odor of iodoform strong ---------- *Poria asiatica*
1	1	1	1	9	1	2	2	4	2	2	---------- *Poria asiatica*
1	1	1	1	9	2	1	2	2	2	2	---------- *Pholiota adiposa*
1	1	1	1	9	2	1	2	3	2	2	---------- *Pholiota adiposa*
1	1	1	1	9	2	2	1	4	2	1	---------- *Polyporus umbellatus*
1	1	1	1	9	2	2	1	4	2	2	---------- *Polyporus squamosus* *Polyporus umbellatus*
1	1	1	1	9	2	2	2	1	1	2	---------- *Polyporus hirsutus* *Polyporus pubescens*
1	1	1	1	9	2	2	2	1	1	3	---------- *Polyporus pubescens*
1	1	1	1	9	2	2	2	1	2	2	Mat at first floccose-woolly, becoming patchy, with some areas raised, felty-woolly, intervening areas appressed, thin felty------ *Lenzites betulina*
											Mat woolly-felty to plasterlike, with large compact lumps---------- *Polyporus hirsutus*
											Mat cottony at first, then uniformly felty, more or less pitted---------- *Polyporus pubescens*
											Mat uniformly cottony-woolly to felty, frequently with minute papillae where mat is grown against side of Petri dish---------- *Poria subacida*
1	1	1	1	9	2	2	2	1	2	3	Mat at first woolly-floccose, becoming appressed, woolly-felty, with slightly raised reticulations ---------- *Daedalea unicolor*
											Mat appressed, subfelty to floccose to somewhat pitted, except in part remote from inoculum where it is raised, woolly---------- *Polyporus conchifer*
											Mat cottony at first, then uniformly felty, more or less pitted---------- *Polyporus pubescens*
											Mat raised, cottony-woolly in newer growth and remaining so in some areas, otherwise felty, with drops of exudate that may leave surface punctate ---------- *Polyporus versicolor*
											Mat uniformly cottony-woolly to felty, frequently with minute papillae grown against side of Petri dish ---------- *Poria subacida*
1	1	1	1	9	2	2	2	2	1	1	---------- *Fomes roseus*
1	1	1	1	9	2	2	2	2	1	2	Mat pale pink, fruiting surface diffuse, granular to irregularly pored---------- *Fomes roseus*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	1	1	1	9	2	2	2	2	1	2	Mat white, fruit bodies distorted mushrooms with gills ---------- *Pleurotus ostreatus*
											Mat white, pored fruiting surfaces formed on large lumps over inoculum and elsewhere ---------- *Polyporus hirsutus*
											Mat white, fruit bodies with gills, normal or distorted ---------- *Schizophyllum commune*
1	1	1	1	9	2	2	2	2	2	2	Mat usually becoming buffy brown to olive brown in small areas and in lines traversing white mat, thong-like strands grown through agar conspicuous from lower side---------- *Collybia radicata*
											Mat white, appressed downy; occurring only on *Shepherdia argentea*-------- *Fomes Ellisianus*
											Mat at first floccose-woolly, becoming patchy, with some areas raised, felty-woolly, intervening areas appressed, thin felty------ *Lenzites betulina*
											Mat white, appressed, woolly-felty, with slightly raised tufts arranged in more or less concentric lines, producing zonate appearance ---------- *Pleurotus ostreatus*
											Mat woolly-felty to plasterlike, with large compact lumps---------- *Polyporus hirsutus*
											Mat uniformly cottony-woolly to felty, frequently with minute papillae grown against side of Petri dish ---------- *Poria subacida*
											Mat raised woolly, with scattered, more or less compact lumps---------- *Schizophyllum commune*
1	1	1	1	9	2	2	2	2	2	3	Mat appressed, subfelty to floccose to somewhat pitted, except in part remote from inoculum where it is raised, woolly---------- *Polyporus conchifer*
											Mat raised, cottony-woolly in newer growth and remaining so in some areas, otherwise felty, with drops of exudate that may leave surface punctate ---------- *Polyporus versicolor*
											Mat uniformly cottony-woolly to felty, frequently with minute papillae grown against side of Petri dish---------- *Poria subacida*
1	1	1	1	9	2	2	2	3	2	2	---------- *Favolus alveolaris* *Fomes Ellisianus*
1	1	1	1	9	2	2	2	3	2	3	---------- *Favolus alveolaris*
1	1	1	1	9	2	2	2	4	2	2	---------- *Fomes ohiensis* *Stereum Murrai*
1	1	1	2	7	2	2	2	4	2	2	---------- *Fomes connatus* *Trametes tenuis*
1	1	1	2	9	1	1	2	3	2	2	---------- *Polyporus Berkeleyi*
1	1	1	2	9	1	2	2	3	1	2	---------- *Polyporus Berkeleyi*
1	1	1	2	9	2	1	2	1	2	2	---------- *Fomes annosus*
1	1	1	2	9	2	1	2	4	2	2	---------- *Fomes annosus*
1	1	1	2	9	2	2	2	1	2	1	---------- *Hymenochaete corrugata*
1	1	1	2	9	2	2	2	1	2	2	---------- *Hymenochaete corrugata*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	1	1	2	9	2	2	2	1	2	3	*Polyporus Tulipiferae*
1	1	1	2	9	2	2	2	2	2	1	*Hymenochaete corrugata* *Polyporus dryophilus*
1	1	1	2	9	2	2	2	2	2	2	*Hymenochaete corrugata*
1	1	1	2	9	2	2	2	2	2	3	*Polyporus dryophilus* *Polyporus Tulipiferae*
1	1	1	2	9	2	2	2	3	2	1	*Polyporus dryophilus*
1	1	1	2	9	2	2	2	3	2	2	*Poria ferrea*
1	1	1	2	9	2	2	2	3	2	3	*Polyporus dryophilus* *Poria ferrea*
1	1	1	2	9	2	2	2	4	2	2	*Fomes connatus* *Trametes tenuis*
1	1	1	3	8	1	2	2	1	2	2	*Polyporus resinosus*
1	1	1	3	8	1	2	2	1	2	3	*Polyporus resinosus*
1	1	1	3	8	2	2	2	1	2	2	*Polyporus resinosus*
1	1	1	3	8	2	2	2	1	2	3	*Polyporus resinosus*
1	1	1	3	9	1	2	1	1	2	2	*Poria albipellucida* *Poria cinerescens*
1	1	1	3	9	1	2	1	1	2	3	*Poria albipellucida* *Poria cinerescens*
1	1	1	3	9	1	2	2	1	2	2	*Polyporus resinosus* *Poria albipellucida* *Poria cinerescens*
1	1	1	3	9	1	2	2	1	2	3	Mat at first all downy, later with woolly areas, appearing patchy; chlamydospores numerous, globose to ovoid, 6.0–12.0μ diameter; no odor ..... *Polyporus galactinus* Mat at first thin woolly and subfelty, later with raised cottony areas, appearing patchy; chlamydospores numerous to rare, 16.0–24.0 × 9.0–16.5μ; odor strong, sweet ..... *Polyporus resinosus* Mat patchy, with conspicuous V-shaped thickenings, opaque because of denser growth within agar and fine woolly to farinaceous surface; chlamydospores usually numerous, 7.5–10.5μ diameter; odor of apples ..... *Poria albipellucida* *Poria cinerescens*
1	1	1	3	9	2	2	2	1	2	2	*Polyporus resinosus*
1	1	1	3	9	2	2	2	1	2	3	*Polyporus resinosus*
1	1	2	1	9	1	2	2	1	1	2	*Poria monticola*
1	1	2	1	9	1	2	2	1	2	2	*Poria monticola*
1	1	2	1	9	1	2	2	2	1	2	Mat white, woolly-felty, with slightly raised reticulations, fruiting over raised tufts; chlamydospores numerous, thick-walled, 12.0–18.0 × 7.5–13.5μ; basidiospores oblong-ellipsoid to cylindric, 6.0–8.0 × 2.5–3.0μ ..... *Daedalea quercina* Mat pink, downy to floccose, fruiting over most of surface; chlamydospores rare, thin-walled, 10.5–24.0 × 6.0–7.5μ; basidiospores cylindric, curved, 6.0–8.0 × 1.5–2.0μ ..... *Fomes subroseus*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	1	2	1	9	1	2	2	2	1	2	Mat white, cottony, translucent except for opaque dots or larger areas, subfelty to waxy, minutely pored; chlamydospores numerous, with walls somewhat thickened, 7.5–13.5 × 4.5–9.0μ; basidiospores ellipsoid to oblong, 3.6–4.5 × 2.7μ ---------- *Polyporus fumosus*
											Mat white, raised woolly, with typical or distorted fruit bodies; chlamydospores with walls slightly thickened, 6.0–15.0 × 4.5–7.5μ; basidiospores cylindric, 3.0–4.0 × 1.5μ *Schizophyllum commune*
											Mat white or with tinge of pale "cartridge buff" to "cinnamon-buff", cottony to woolly, forming foliose fruit bodies; chlamydospores numerous to rare, with walls slightly thickened, 8.0–19.5 × 6.0–13.5μ; basidiospores oblong-ellipsoid, 4.5–6.0 × 2.2–2.7μ ---------- *Poria monticola*
											Mat white, newest growth raised, cottony, then collapsed, leaving thin film on agar; chlamydospores rare or apparently lacking, 10.5–19.5 × 6.0–7.5μ; basidiospores cylindric, slightly curved, 4.2–5.0 × 1.2μ ---------- *Poria xantha*
1	1	2	1	9	1	2	2	2	2	2	Mat white, cottony-woolly; chlamydospores numerous in some isolates, usually limited to advancing zone, 6.0–18.0 × 6.0–9.0μ ---------- *Fomes pinicola*
											(See immediately above) *Daedalea quercina* *Polyporus fumosus* *Poria monticola* *Poria xantha* *Schizophyllum commune*
1	1	2	1	9	1	2	2	3	2	2	---------- *Fomes pinicola* *Poria asiatica*
1	1	2	1	9	1	2	2	4	2	2	---------- *Poria asiatica*
1	1	2	1	9	2	2	1	1	2	2	---------- *Polyporus adustus*
1	1	2	1	9	2	2	1	1	2	3	---------- *Polyporus adustus*
1	1	2	1	9	2	2	2	1	1	2	---------- *Polyporus betulinus*
1	1	2	1	9	2	2	2	1	2	2	Mat thin, cottony-woolly to woolly-floccose in newest growth, finally collapsed and felty; good growth on gallic acid agar, no growth on tannic acid agar; oidia usually present ---------- *Polyporus adustus*
											Mat slightly raised, cottony-floccose, so thin as to be translucent, becoming collapsed, with scattered dots or balls of more compact mycelium; good growth on both gallic and tannic acid agars ---------- *Polyporus betulinus*
											Mat all submerged or appressed or with some areas developing powdery to floccose or tufted mycelium; reverse in some isolates greenish-yellow; no growth or only a trace on gallic and tannic acid agars ---------- *Polyporus dichrous*
1	1	2	1	9	2	2	2	1	2	3	---------- *Polyporus adustus*
1	1	2	1	9	2	2	2	2	1	1	---------- *Fomes roseus*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	1	2	1	9	2	2	2	2	1	2	Mat pale pink; fruiting surface diffuse, granular to irregularly pored----------*Fomes roseus*
											Mat white, fruit bodies distorted mushrooms with gills----------*Pleurotus ostreatus*
											Mat white, fruiting in minutely pored areas on surface ----------*Poria xantha*
											Mat white, fruiting over small compact balls usually grown against side wall of Petri dish, pored ----------*Polyporus betulinus*
											Mat white, fruit bodies with gills, normal or distorted ----------*Schizophyllum commune*
1	1	2	1	9	2	2	2	2	2	2	Mat cottony-woolly, usually uniform in appearance; diameter on gallic acid agar 1.5–4.0 cm., on tannic acid agar trace to 3.0 cm.--*Fomes pinicola*
											Mat appressed, woolly-felty, with slightly raised tufts, arranged in more or less concentric lines, producing zonate appearance; no growth on gallic or tannic acid agars----------*Pleurotus ostreatus*
											Mat slightly raised, cottony-floccose, so thin as to be translucent, becoming collapsed, with scattered dots or balls of more compact mycelium; good growth on both gallic and tannic acid agars ----------*Polyporus betulinus*
											Mat all submerged or appressed or with some areas developing powdery to floccose or tufted mycelium; reverse in some isolates greenish-yellow; no growth or only a trace on gallic and tannic acid agars ----------*Polyporus dichrous*
											Mat raised in newest growth, cottony, then collapsed, leaving thin film on agar; good growth on gallic acid agar, no growth on tannic acid agar ----------*Poria xantha*
											Mat raised woolly, with scattered more or less compact lumps; good growth on both gallic and tannic acid agars----------*Schizophyllum commune*
1	1	2	1	9	2	2	2	3	1	2	----------*Trametes sepium* *Trametes serialis*
1	1	2	1	9	2	2	2	3	2	2	Mat cottony-woolly, usually uniform in appearance; diameter on gallic acid agar 1.5–4.0 cm., on tannic acid agar trace to 3.0 cm. diameter ----------*Fomes pinicola*
											Mat raised, loosely arranged, tangled, cottony; no growth on gallic and tannic acid agars ----------*Pleurotus ulmarius*
											Mat raised, cobwebby-cottony to plumose, becoming collapsed and appressed in older part; good growth on gallic acid agar, no growth on tannic acid agar ----------*Polyporus subcartilagineus*
											Mat appressed downy in newest growth, so thin as to be translucent, soon developing zones in which mycelium is slightly raised, woolly, opaque; good growth on gallic acid agar, trace on tannic acid agar ----------*Trametes sepium*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	1	2	1	9	2	2	2	4	2	2	*Pleurotus ulmarius*
1	1	2	2	1	2	2	2	2	1	2	*Polyporus fibrillosus*
1	1	2	2	9	1	1	2	2	2	2	*Polyporus sulphureus*
1	1	2	2	9	1	2	2	2	2	2	*Polyporus sulphureus*
1	1	2	2	9	2	2	2	1	2	3	*Polyporus Tulipiferae*
1	1	2	2	9	2	2	2	2	2	3	*Polyporus Tulipiferae*
1	1	2	4	9	2	2	1	1	2	1	*Coniophora puteana*
1	1	2	4	9	2	2	1	1	2	2	*Coniophora puteana*
1	1	2	4	9	2	2	2	1	2	1	*Coniophora puteana*
1	1	2	4	9	2	2	2	1	2	2	*Coniophora puteana*
1	2	1	1	5	1	2	2	1	2	3	*Ganoderma lucidum*
1	2	1	1	5	2	2	1	2	2	1	*Polyporus graveolens*
1	2	1	1	5	2	2	1	2	2	2	*Polyporus graveolens*
1	2	1	1	5	2	2	2	1	2	2	*Fomes fomentarius*
1	2	1	1	5	2	2	2	2	2	2	*Ganoderma applanatum* *Ganoderma lobatum*
1	2	1	1	5	2	2	2	4	2	2	*Ganoderma applanatum*
1	2	1	1	6	1	2	2	1	2	2	*Polyporus arcularius* *Polyporus brumalis*
1	2	1	1	6	1	2	2	1	2	3	*Polyporus arcularius* *Polyporus brumalis*
1	2	1	1	6	1	2	2	2	2	2	*Polyporus brumalis*
1	2	1	1	6	1	2	2	2	2	3	*Polyporus brumalis*
1	2	1	1	6	2	2	1	4	2	2	*Polyporus squamosus*
1	2	1	1	6	2	2	2	1	2	2	*Polyporus brumalis* *Polyporus arcularius*
1	2	1	1	6	2	2	2	1	2	3	*Polyporus arcularius* *Polyporus brumalis*
1	2	1	1	6	2	2	2	2	2	1	*Daedalea confragosa* *Polyporus tuberaster*
1	2	1	1	6	2	2	2	2	2	2	Mat "buffy brown" to "olive-brown" in small areas and in lines traversing white mat; thonglike strands grown through agar conspicuous from lower side ---- *Collybia radicata* Mat white, with patches of "pinkish cinnamon", "cinnamon", and "snuff brown", to "bister", newer growth downy to fine woolly, becoming felty, to chamoislike, and crustose in colored areas ---- *Daedalea confragosa* Mat white with scattered areas of "light vinaceous-cinnamon", "vinaceous-cinnamon", "cinnamon-buff", "tawny-olive", and "sayal brown", coalescing until whole surface is colored and mottled, cottony to woolly ---- *Polyporus brumalis*
1	2	1	1	6	2	2	2	2	2	3	*Polyporus brumalis*
1	2	1	1	6	2	2	2	3	2	1	*Polyporus tuberaster*
1	2	1	1	9	1	2	2	2	1	2	*Polyporus cinnabarinus*
1	2	1	1	9	1	2	2	2	2	2	*Lentinus tigrinus*
1	2	1	1	9	2	1	2	2	1	2	*Polyporus rutilans*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	2	1	1	9	2	1	2	2	2	2	*Pholiota adiposa* *Polyporus rutilans*
1	2	1	1	9	2	1	2	3	2	2	*Pholiota adiposa*
1	2	1	1	9	2	2	1	4	2	2	*Polyporus squamosus*
1	2	1	1	9	2	2	2	1	2	2	*Fomes fomentarius*
1	2	1	1	9	2	2	2	2	1	2	*Fomes scutellatus*
1	2	1	1	9	2	2	2	2	2	1	*Daedalea confragosa* *Polyporus tuberaster*
1	2	1	1	9	2	2	2	2	2	2	Mat "buffy brown" to "olive-brown" in small areas and in lines traversing white mat; thonglike strands grown through agar conspicuous from lower side ---- *Collybia radicata*
											Mat white, with patches of "pinkish cinnamon", and "snuff brown", to "bister", newer growth downy to fine woolly, becoming felty to chamoislike and crustose in colored areas ---- *Daedalea confragosa*
											Mat white, becoming "cream-buff", to "cinnamon-brown" in isolated areas, at first appressed cottony, becoming slightly raised, floccose to cottony-woolly ---- *Fomes scutellatus*
1	2	1	1	9	2	2	2	3	1	2	*Fomes scutellatus*
1	2	1	1	9	2	2	2	3	2	1	*Polyporus tuberaster*
1	2	1	1	9	2	2	2	3	2	2	*Fomes scutellatus*
1	2	1	2	2	2	2	2	2	1	1	*Polyporus gilvus*
1	2	1	2	2	2	2	2	2	1	2	*Polyporus gilvus*
1	2	1	2	2	2	2	2	3	1	1	*Poria obliqua*
1	2	1	2	2	2	2	2	3	1	2	*Poria obliqua*
1	2	1	2	2	2	2	2	4	2	1	Setae numerous in some isolates, rare in others, 30.0–67.0 × 4.5–7.0μ; expansions on brown aerial hyphae up to 7.5μ diameter, occurring singly or in series ---- *Fomes Pini*
											Setae or setal hyphae fairly numerous, 4.5–6.0μ diameter, up to 200μ long; no pseudoparenchymatous layer ---- *Poria ferruginosa*
											Setal hyphae fairly numerous, 4.5–9.0μ diameter, up to 300μ long; pseudoparenchymatous layer composed of brown hyphae with interlocking short branches ---- *Polyporus glomeratus*
1	2	1	2	5	2	2	2	1	2	1	*Fomes igniarius* var. *laevigatus*
1	2	1	2	5	2	2	2	2	2	1	*Fomes igniarius* *F. igniarius* var. *laevigatus*
1	2	1	2	5	2	2	2	3	2	1	*Fomes igniarius*
1	2	1	2	5	2	2	2	4	2	1	*Armillaria mellea* *Fomes igniarius* var. *populinus*
1	2	1	2	5	2	2	2	4	2	2	*Armillaria mellea*
1	2	1	2	6	2	2	2	2	1	2	*Polyporus dryophilus* var. *vulpinus*
1	2	1	2	6	2	2	2	2	2	1	*Polyporus radiatus*
1	2	1	2	6	2	2	2	2	2	2	*Hymenochaete tabacina* *Polyporus dryophilus* var. *vulpinus*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	2	1	2	6	2	2	2	3	1	2	*Polyporus dryophilus* var. *vulpinus*
1	2	1	2	6	2	2	2	3	2	2	*Polyporus dryophilus* var. *vulpinus*
1	2	1	2	6	2	2	2	4	2	1	*Polyporus glomeratus*
1	2	1	2	7	2	2	2	4	2	1	*Fomes conchatus* *Fomes Pini*
1	2	1	2	7	2	2	2	4	2	2	*Trametes tenuis*
1	2	1	2	9	2	1	2	1	2	2	*Fomes annosus*
1	2	1	2	9	2	1	2	4	2	2	*Fomes annosus*
1	2	1	2	9	2	2	2	1	2	1	*Fomes igniarius* var. *laevigatus* *Hymenochaete corrugata*
1	2	1	2	9	2	2	2	1	2	2	*Hymenochaete corrugata*
1	2	1	2	9	2	2	2	2	1	2	*Polyporus cuticularis* *Polyporus dryophilus* var. *vulpinus*
1	2	1	2	9	2	2	2	2	2	1	Mat with conspicuous white border, then "cream-buff", "honey yellow", to "tawny-olive", raised, thick woolly, nodulose; odor fragrant; restricted to species of Rosaceae——*Fomes fulvus*
											Mat with white border, then "cream-buff", "Naples yellow", "mustard yellow", in some isolates "honey yellow", "tawny-olive", "buckthorn brown", downy to cottony-woolly, with or without crustose areas; odor of wintergreen in some isolates——*Fomes igniarius*
											Mat with white border, then "cream-buff", "chamois", "honey yellow", and "clay color", "tawny-olive", "sayal brown", slightly raised cottony in newest growth, then woolly to tufted felty, with or without crustose zones; odor of wintergreen strong——*Fomes igniarius* var. *laevigatus*
											Mat with white border, changing abruptly to "clay color", "yellow ocher", "buckthorn brown", later with brighter colors of "old gold", "mustard yellow", etc., at first appressed, downy to cottony, then cottony-floccose, and finally felty and tufted; restricted to *Robinia pseudoacacia*——*Fomes rimosus*
											Mat with scattered areas and lines "chamois" and "buckthorn brown", slightly raised, woolly; odor sweet——*Hymenochaete corrugata*
											Mat white to "colonial buff", and "chamois", and "honey yellow", deepest color in newest growth, raised, cottony to cottony-woolly, older part collapsed, woolly, usually on *Quercus* spp.——*Polyporus dryophilus*
											Mat white, becoming "snuff brown", "Saccardo's umber", and "sepia" over inoculum and along radiating lines, cottony to felty or velvety——*Polyporus gilvus*
											Mat white, changing to "colonial buff", "chamois" slightly raised, cottony-woolly, somewhat tufted, the older part "olive-ocher", "honey yellow", "Isabella color", appressed, short cottony; slight odor——*Polyporus radiatus*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	2	1	2	9	2	2	2	2	2	2	Mat with conspicuous white border, then "cream-buff", "honey yellow" to "tawny-olive", raised, thick woolly, nodulose; odor fragrant; restricted to species of Rosaceae ---- *Fomes fulvus*
											Mat with scattered areas and lines "chamois" and "buckthorn brown", slightly raised, woolly; odor sweet ---- *Hymenochaete corrugata*
											Mat white to "colonial buff" and "Isabella color", to "tawny-olive" in some isolates, newest growth raised, loosely arranged, cottony, later appressed, woolly to subfelty ---- *Polyporus cuticularis*
											Mat with white border, then "colonial buff", "chamois", "deep colonial buff", "honey yellow", and "Isabella color", usually paler in older part, raised, cottony to cottony-plumose, collapsed around inoculum, subfelty to skinlike ---- *Polyporus dryophilus* var. *vulpinus*
											Mat white, becoming "snuff brown", "Saccardo's umber", and "sepia" over inoculum and along radiating lines, cottony to felty or velvety ---- *Polyporus gilvus*
1	2	1	2	9	2	2	2	2	2	3	---- *Polyporus dryophilus*
1	2	1	2	9	2	2	2	3	1	1	---- *Polyporus cuticularis*
1	2	1	2	9	2	2	2	3	1	2	---- *Polyporus dryophilus* var. *vulpinus*
1	2	1	2	9	2	2	2	3	2	1	Mat white to "baryta yellow", "light cadmium", and "yellow ocher", erect, silky-cottony, zonate, later developing opaque, azonate areas, "cream-buff", "chamois", and "honey-yellow" ---- *Fomes Everhartii*
											Mat with white border, then "cream-buff", "Naples yellow", "mustard yellow", in some isolates "honey yellow", "tawny-olive", "buckthorn brown", downy to cottony-woolly, with or without crustose areas; odor of wintergreen in some isolates ---- *Fomes igniarius*
											Mat with white border, changing abruptly to "clay color", "yellow ocher", "buckthorn brown", later with brighter colors of "old gold", "mustard yellow", etc., at first appressed, downy to cottony, then cottony-floccose, and finally felty and tufted; restricted to *Robinia pseudoacacia* ---- *Fomes rimosus*
											Mat white to "colonial buff" and "Isabella color", to "tawny-olive" in some isolates, newest growth raised, loosely arranged, cottony, later appressed, woolly to subfelty ---- *Polyporus cuticularis*
											Mat white to "colonial buff", "chamois", and "honey yellow", deepest color in newest growth, raised, cottony to cottony-woolly, older part collapsed, woolly; usually on *Quercus* spp. ---- *Polyporus dryophilus*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	2	1	2	9	2	2	2	3	2	2	Mat with white border, then "colonial buff", "chamois" "deep colonial buff", "honey yellow", and "Isabella color", usually paler in older part, raised, cottony to cottony-plumose, collapsed around inoculum, subfelty to skinlike--*Polyporus dryophilus* var. *vulpinus*
											Mat white with tinges of "tawny-olive" and "buckthorn brown" over inoculum, and after three to four weeks in scattered flecks or narrow zones, appressed, cottony----------*Poria ferrea*
											Mat white at first, then "pinkish buff", "chamois", and "tawny-olive", raised to top of Petri dish in vicinity of inoculum and gradually sloping to level of agar at margin, thin woolly----*Poria punctata*
1	2	1	2	9	2	2	2	3	2	3	----------*Polyporus dryophilus* *Poria ferrea*
1	2	1	2	9	2	2	2	4	2	1	Mat white to "cream-buff" and "chamois", raised, thick woolly, or white to "mustard yellow", "primuline yellow", "chamois", and "honey yellow", to "olive-ocher", cottony, so thin as to allow color of agar to show through, or showing sectors of both types of growth----------*Fomes conchatus*
											Mat white to "baryta yellow", "light cadmium", and "yellow ocher", erect, silky-cottony, zonate, later developing opaque, azonate areas, "cream-buff", "chamois", and "honey yellow" ----------*Fomes Everhartii*
											Mat with white border, then "colonial buff", "old gold", "honey yellow", "Saccardo's umber", "cinnamon-brown", raised, thick woolly to plushlike, with radiating grooves; strong odor of wintergreen; restricted to *Populus* spp. ----------*Fomes igniarius* var. *populinus*
											Mat with narrow white border, then "yellow ocher" to "snuff brown", "old gold","Dresden brown","Sudan brown", etc., the paler areas thin woolly-felty, the reddish brown areas velvety ----------*Polyporus dryadeus*
											Mat patchy, white to "barium yellow", "wax yellow", "yellow ocher", and "olive-yellow", cottony to woolly, sometimes zonate; setal hyphae and cuticular cells usually present-------*Polyporus glomeratus*
1	2	1	2	9	2	2	2	4	2	2	----------*Trametes tenuis*
1	2	2	1	8	2	2	1	2	2	2	----------*Collybia velutipes*
1	2	2	1	9	1	2	1	2	1	2	----------*Lenzites trabea*
1	2	2	1	9	1	2	1	2	2	2	----------*Lenzites saepiaria*
1	2	2	1	9	1	2	1	3	2	2	----------*Lenzites saepiaria*
1	2	2	1	9	1	2	1	4	2	2	----------*Lenzites saepiaria*
1	2	2	1	9	2	1	2	2	2	2	----------*Polyporus guttulatus*
1	2	2	1	9	2	2	1	2	2	2	----------*Collybia velutipes* *Lenzites saepiaria*
1	2	2	1	9	2	2	1	3	2	2	----------*Lenzites saepiaria*
1	2	2	1	9	2	2	1	4	2	2	----------*Lenzites saepiaria*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	2	2	4	9	2	2	1	1	2	1	*Coniophora puteana*
1	2	2	4	9	2	2	1	1	2	2	*Coniophora puteana*
1	2	2	4	9	2	2	2	1	2	1	*Coniophora puteana*
1	2	2	4	9	2	2	2	1	2	2	*Coniophora puteana*
2	1	1	1	0	1	2	2	2	1	2	*Polyporus borealis*
2	1	1	1	0	1	2	2	3	1	2	*Polyporus borealis*
2	1	1	1	0	2	2	2	4	2	1	*Polyporus semipileatus*
2	1	1	1	0	2	2	2	4	2	2	*Polyporus semipileatus*
2	1	1	1	1	1	2	2	2	1	2	*Polyporus borealis*
2	1	1	1	1	1	2	2	3	1	2	*Polyporus borealis*
2	1	1	1	1	1	2	2	4	2	1	*Echinodontium tinctorium*
2	1	1	1	1	2	2	2	2	1	2	*Polyporus pargamenus*
2	1	1	1	1	2	2	2	2	2	2	*Polyporus abietinus* *Polyporus pargamenus*
2	1	1	1	5	2	2	2	2	2	1	*Ganoderma oregonense*
2	1	1	1	5	2	2	2	2	2	2	Fiber hyphae numerous; widely distributed, but rarely encountered on coniferous trees ---- *Ganoderma applanatum*
											Fiber hyphae lacking; limited to western coniferous trees ---- *Ganoderma oregonense*
											Fiber hyphae numerous; limited to eastern coniferous trees ---- *Ganoderma Tsugae*
2	1	1	1	5	2	2	2	2	2	3	*Ganoderma Tsugae*
2	1	1	1	5	2	2	2	4	2	2	*Ganoderma applanatum*
2	1	1	1	6	2	2	2	2	2	2	*Collybia radicata*
2	1	1	1	7	2	2	2	2	2	2	*Polyporus volvatus*
2	1	1	1	7	2	2	2	3	2	2	*Polyporus volvatus*
2	1	1	1	7	2	2	2	4	1	2	*Polyporus amorphus*
2	1	1	1	7	2	2	2	4	2	2	*Polyporus amorphus*
2	1	1	1	9	1	2	2	1	1	2	*Polyporus hirsutus*
2	1	1	1	9	1	2	2	1	2	2	*Polyporus hirsutus*
2	1	1	1	9	1	2	2	1	2	3	*Polyporus versicolor*
2	1	1	1	9	1	2	2	2	1	2	*Fomes subroseus* *Polyporus hirsutus*
2	1	1	1	9	1	2	2	2	2	2	*Polyporus hirsutus*
2	1	1	1	9	1	2	2	2	2	3	*Polyporus versicolor*
2	1	1	1	9	1	2	2	3	2	2	*Poria asiatica*
2	1	1	1	9	1	2	2	4	2	1	*Echinodontium tinctorium*
2	1	1	1	9	1	2	2	4	2	2	*Poria asiatica*
2	1	1	1	9	2	1	2	2	2	2	*Pholiota adiposa*
2	1	1	1	9	2	1	2	3	2	2	*Pholiota adiposa*
2	1	1	1	9	2	2	2	1	1	2	*Polyporus anceps* *Polyporus hirsutus*
2	1	1	1	9	2	2	2	1	2	2	Mat at first floccose-woolly, becoming patchy, with some areas raised, felty-woolly, intervening areas appressed, thin felty ---- *Lenzites betulina*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	2	1	2	9	2	2	2	3	2	2	Mat with white border, then "colonial buff", "chamois" "deep colonial buff", "honey yellow", and "Isabella color", usually paler in older part, raised, cottony to cottony-plumose, collapsed around inoculum, subfelty to skinlike.. *Polyporus dryophilus* var. *vulpinus*
											Mat white with tinges of "tawny-olive" and "buckthorn brown" over inoculum, and after three to four weeks in scattered flecks or narrow zones, appressed, cottony *Poria ferrea*
											Mat white at first, then "pinkish buff", "chamois", and "tawny-olive", raised to top of Petri dish in vicinity of inoculum and gradually sloping to level of agar at margin, thin woolly *Poria punctata*
1	2	1	2	9	2	2	2	3	2	3	*Polyporus dryophilus* *Poria ferrea*
1	2	1	2	9	2	2	2	4	2	1	Mat white to "cream-buff" and "chamois", raised, thick woolly, or white to "mustard yellow", "primuline yellow", "chamois", and "honey yellow", to "olive-ocher", cottony, so thin as to allow color of agar to show through, or showing sectors of both types of growth *Fomes conchatus*
											Mat white to "baryta yellow", "light cadmium", and "yellow ocher", erect, silky-cottony, zonate, later developing opaque, azonate areas, "cream-buff", "chamois", and "honey yellow" *Fomes Everhartii*
											Mat with white border, then "colonial buff", "old gold", "honey yellow", "Saccardo's umber", "cinnamon-brown", raised, thick woolly to plushlike, with radiating grooves; strong odor of wintergreen; restricted to *Populus* spp. *Fomes igniarius* var. *populinus*
											Mat with narrow white border, then "yellow ocher" to "snuff brown", "old gold","Dresden brown","Sudan brown", etc., the paler areas thin woolly-felty, the reddish brown areas velvety *Polyporus dryadeus*
											Mat patchy, white to "barium yellow", "wax yellow", "yellow ocher", and "olive-yellow", cottony to woolly, sometimes zonate; setal hyphae and cuticular cells usually present *Polyporus glomeratus*
1	2	1	2	9	2	2	2	4	2	2	*Trametes tenuis*
1	2	2	1	8	2	2	1	2	2	2	*Collybia velutipes*
1	2	2	1	9	1	2	1	2	1	2	*Lenzites trabea*
1	2	2	1	9	1	2	1	2	2	2	*Lenzites saepiaria*
1	2	2	1	9	1	2	1	3	2	2	*Lenzites saepiaria*
1	2	2	1	9	1	2	1	4	2	2	*Lenzites saepiaria*
1	2	2	1	9	2	1	2	2	2	2	*Polyporus guttulatus*
1	2	2	1	9	2	2	1	2	2	2	*Collybia velutipes* *Lenzites saepiaria*
1	2	2	1	9	2	2	1	3	2	2	*Lenzites saepiaria*
1	2	2	1	9	2	2	1	4	2	2	*Lenzites saepiaria*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
1	2	2	4	9	2	2	1	1	2	1	*Coniophora puteana*
1	2	2	4	9	2	2	1	1	2	2	*Coniophora puteana*
1	2	2	4	9	2	2	2	1	2	1	*Coniophora puteana*
1	2	2	4	9	2	2	2	1	2	2	*Coniophora puteana*
2	1	1	1	0	1	2	2	2	1	2	*Polyporus borealis*
2	1	1	1	0	1	2	2	3	1	2	*Polyporus borealis*
2	1	1	1	0	2	2	2	4	2	1	*Polyporus semipileatus*
2	1	1	1	0	2	2	2	4	2	2	*Polyporus semipileatus*
2	1	1	1	1	1	2	2	2	1	2	*Polyporus borealis*
2	1	1	1	1	1	2	2	3	1	2	*Polyporus borealis*
2	1	1	1	1	1	2	2	4	2	1	*Echinodontium tinctorium*
2	1	1	1	1	2	2	2	2	1	2	*Polyporus pargamenus*
2	1	1	1	1	2	2	2	2	2	2	*Polyporus abietinus* *Polyporus pargamenus*
2	1	1	1	5	2	2	2	2	2	1	*Ganoderma oregonense*
2	1	1	1	5	2	2	2	2	2	2	Fiber hyphae numerous; widely distributed, but rarely encountered on coniferous trees ---- *Ganoderma applanatum* Fiber hyphae lacking; limited to western coniferous trees ---- *Ganoderma oregonense* Fiber hyphae numerous; limited to eastern coniferous trees ---- *Ganoderma Tsugae*
2	1	1	1	5	2	2	2	2	2	3	*Ganoderma Tsugae*
2	1	1	1	5	2	2	2	4	2	2	*Ganoderma applanatum*
2	1	1	1	6	2	2	2	2	2	2	*Collybia radicata*
2	1	1	1	7	2	2	2	2	2	2	*Polyporus volvatus*
2	1	1	1	7	2	2	2	3	2	2	*Polyporus volvatus*
2	1	1	1	7	2	2	2	4	1	2	*Polyporus amorphus*
2	1	1	1	7	2	2	2	4	2	2	*Polyporus amorphus*
2	1	1	1	9	1	2	2	1	1	2	*Polyporus hirsutus*
2	1	1	1	9	1	2	2	1	2	2	*Polyporus hirsutus*
2	1	1	1	9	1	2	2	1	2	3	*Polyporus versicolor*
2	1	1	1	9	1	2	2	2	1	2	*Fomes subroseus* *Polyporus hirsutus*
2	1	1	1	9	1	2	2	2	2	2	*Polyporus hirsutus*
2	1	1	1	9	1	2	2	2	2	3	*Polyporus versicolor*
2	1	1	1	9	1	2	2	3	2	2	*Poria asiatica*
2	1	1	1	9	1	2	2	4	2	1	*Echinodontium tinctorium*
2	1	1	1	9	1	2	2	4	2	2	*Poria asiatica*
2	1	1	1	9	2	1	2	2	2	2	*Pholiota adiposa*
2	1	1	1	9	2	1	2	3	2	2	*Pholiota adiposa*
2	1	1	1	9	2	2	2	1	1	2	*Polyporus anceps* *Polyporus hirsutus*
2	1	1	1	9	2	2	2	1	2	2	Mat at first floccose-woolly, becoming patchy, with some areas raised, felty-woolly, intervening areas appressed, thin felty ---- *Lenzites betulina*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
2	1	1	1	9	2	2	2	1	2	2	Mat woolly-felty to plasterlike, with large compact lumps---*Polyporus hirsutus*
											Mat uniformly cottony-woolly to felty, frequently with minute papillae where mat is grown against side of Petri dish---*Poria subacida*
2	1	1	1	9	2	2	2	1	2	3	Mat at first woolly-floccose, becoming appressed woolly-felty, with slightly raised reticulations---*Daedalea unicolor*
											Mat raised, cottony-woolly in newer growth and remaining so in some areas, otherwise felty, with drops of exudate that may leave surface punctate---*Polyporus versicolor*
											Mat uniformly cottony-woolly to felty, frequently with minute papillae grown against side of Petri dish---*Poria subacida*
2	1	1	1	9	2	2	2	2	1	1	---*Fomes roseus*
2	1	1	1	9	2	2	2	2	1	2	Mat pale pink, fruiting surface diffuse, granular to irregularly pored---*Fomes roseus*
											Mat white, fruit bodies distorted mushrooms with gills---*Pleurotus ostreatus*
											Mat white, pored fruiting surfaces formed on large lumps over inoculum and elsewhere---*Polyporus hirsutus*
2	1	1	1	9	2	2	2	2	2	2	Mat usually becoming "buffy brown" to "olive-brown" in small areas and in lines traversing white mat; thonglike strands grown through agar conspicuous from lower side---*Collybia radicata*
											Mat white, at first floccose-woolly, becoming patchy, with some areas raised, felty-woolly, intervening areas appressed, thin felty---*Lenzites betulina*
											Mat white, appressed, woolly-felty, with slightly raised tufts arranged in more or less concentric lines, producing zonate appearance---*Pleurotus ostreatus*
											Mat white, woolly-felty to plasterlike, with large compact lumps---*Polyporus hirsutus*
											Mat white, uniformly cottony-woolly to felty, frequently with minute papillae grown against side of Petri dish---*Poria subacida*
2	1	1	1	9	2	2	2	2	2	3	---*Polyporus versicolor* *Poria subacida*
2	1	1	1	9	2	2	2	4	1	2	---*Polyporus amorphus*
2	1	1	1	9	2	2	2	4	2	2	---*Polyporus amorphus*
2	1	1	2	7	2	2	2	4	2	2	---*Trametes tenuis*
2	1	1	2	9	1	1	2	3	2	2	---*Polyporus Berkeleyi*
2	1	1	2	9	1	2	2	3	1	2	---*Polyporus Berkeleyi*
2	1	1	2	9	1	2	2	3	2	2	---*Polyporus montanus*
2	1	1	2	9	2	1	2	1	2	2	---*Fomes annosus*
2	1	1	2	9	2	1	2	4	2	2	---*Fomes annosus*
2	1	1	2	9	2	2	1	1	2	2	---*Peniophora gigantea*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
2	1	1	2	9	2	2	1	2	2	2	*Peniophora gigantea*
2	1	1	2	9	2	2	2	1	2	1	*Hymenochaete corrugata*
2	1	1	2	9	2	2	2	1	2	2	*Hymenochaete corrugata*
2	1	1	2	9	2	2	2	2	2	1	*Hymenochaete corrugata*
2	1	1	2	9	2	2	2	2	2	2	*Hymenochaete corrugata*
2	1	1	2	9	2	2	2	3	2	2	*Polyporus montanus* *Poria ferrea*
2	1	1	2	9	2	2	2	3	2	3	*Poria ferrea*
2	1	1	2	9	2	2	2	4	2	2	*Trametes tenuis*
2	1	1	3	8	1	2	2	1	2	2	*Polyporus resinosus*
2	1	1	3	8	1	2	2	1	2	3	*Polyporus resinosus*
2	1	1	3	8	2	2	2	1	2	2	*Polyporus resinosus*
2	1	1	3	8	2	2	2	1	2	3	*Polyporus resinosus*
2	1	1	3	9	1	2	1	1	2	2	*Poria albipellucida* *Poria cinerescens*
2	1	1	3	9	1	2	1	1	2	3	*Poria albipellucida* *Poria cinerescens*
2	1	1	3	9	1	2	2	1	2	2	*Polyporus resinosus* *Poria albipellucida* *Poria cinerescens*
2	1	1	3	9	1	2	2	1	2	3	*Polyporus resinosus* *Poria albipellucida* *Poria cinerescens*
2	1	1	3	9	1	2	2	2	2	2	*Lentinus lepideus*
2	1	1	3	9	2	2	2	1	2	2	*Polyporus resinosus*
2	1	1	3	9	2	2	2	1	2	3	*Polyporus resinosus*
2	1	1	3	9	2	2	2	2	2	2	*Lentinus Kauffmanii*
2	1	1	3	9	2	2	2	3	2	2	*Lentinus Kauffmanii*
2	1	1	4	1	2	2	2	2	2	2	*Stereum sanguinolentum*
2	1	1	4	1	2	2	2	3	2	2	*Stereum sanguinolentum*
2	1	1	4	9	2	2	2	2	2	2	*Stereum sanguinolentum*
2	1	1	4	9	2	2	2	3	2	2	*Stereum sanguinolentum*
2	1	2	1	4	1	1	2	2	2	2	*Poria carbonica*
2	1	2	1	4	1	1	2	3	2	2	*Poria carbonica*
2	1	2	1	9	1	1	2	4	2	2	*Fomes officinalis*
2	1	2	1	9	1	2	1	2	2	2	*Trametes americana*
2	1	2	1	9	1	2	1	3	2	2	*Trametes americana*
2	1	2	1	9	1	2	2	1	1	2	*Poria monticola*
2	1	2	1	9	1	2	2	1	2	2	*Poria monticola*
2	1	2	1	9	1	2	2	2	1	1	*Polyporus balsameus*
2	1	2	1	9	1	2	2	2	1	2	Mat pink, downy to floccose, fruiting over most of surface; chlamydospores rare, thin-walled, 10.5–24.0 × 6.0–7.5μ; basidiospores cylindric, curved, 6.0–8.0 × 1.5–2.0μ ..... *Fomes subroseus* Mat white or "pinkish buff" and "cinnamon" in older part, cottony, becoming coarse plumose or tufted, or with aerial mycelium scanty, appressed, downy, forming waxy pored fruiting surface; chlamydospores buffy brown when mature, 7.5–16.5×4.5–9.0μ ..... *Polyporus balsameus*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
2	1	2	1	9	1	2	2	2	1	2	Mat white, slightly raised, downy to cottony floccose or thin felty, with scattered small raised balls of compact mycelium with surface at first floccose, later compact and covered with pores; chlamydospores rare, hyaline, 10.5–19.5 × 7.5–12.0μ; basidiospores cylindric, 6.0–9.0 × 2.0–3.0μ ---------- *Polyporus palustris*
											Mat white or with tinge of pale "cartridge buff" to "cinnamon buff", cottony to woolly, forming foliose fruit bodies; chlamydospores numerous to rare, with walls slightly thickened, 8.0–19.5 × 6.0–13.5μ; basidiospores oblong-ellipsoid, 4.5–6.0 × 2.2–2.7μ ---------- *Poria monticola*
											Mat white, newest growth raised, cottony, then collapsed, leaving thin film on agar; chlamydospores rare or apparently lacking, 10.6–19.5 × 6.0–7.5μ; basidiospores cylindric, slightly curved, 4.2–5.0 × 1.2μ ---------- *Poria xantha*
2	1	2	1	9	1	2	2	2	2	1	---------- *Polyporus balsameus*
2	1	2	1	9	1	2	2	2	2	2	Mat white, cottony-woolly; chlamydospores numerous in some isolates, usually limited to advancing zone, 6.0–18.0 × 6.0–9.0μ ---------- *Fomes pinicola*
											(See immediately above) *Polyporus balsameus*, *Poria monticola*, *Poria xantha*
											Mat white or becoming "cream-buff", "chamois", and "honey yellow" over oldest parts, at first short cottony, later woolly, opaque; chlamydospores fairly numerous, 9.0–21.0 × 7.5–12.0μ ---------- *Trametes americana*
2	1	2	1	9	1	2	2	3	1	1	---------- *Polyporus balsameus*
2	1	2	1	9	1	2	2	3	1	2	---------- *Polyporus balsameus*
2	1	2	1	9	1	2	2	3	2	1	---------- *Polyporus balsameus*
2	1	2	1	9	1	2	2	3	2	2	Mat white, cottony-woolly; chlamydospores numerous in some isolates, usually limited to advancing zone, 6.0–18.0 × 6.0–9.0μ ---------- *Fomes pinicola*
											Mat white or "pinkish buff" and "cinnamon" in older part, cottony, becoming coarse plumose or tufted, or with aerial mycelium scanty, appressed, downy; chlamydospores buffy brown when mature, 7.5–16.5 × 4.5–9.0μ ---------- *Polyporus balsameus*
											Mat white, raised, cottony-floccose in newer growth, becoming more compact, at least in part; chlamydospores numerous, usually rough-walled, 7.5–21.0 × 4.5–12.0μ; odor of iodoform strong ---------- *Poria asiatica*
											Mat white or becoming "cream-buff", "chamois", and "honey yellow" over oldest parts, at first short cottony, later woolly, opaque; chlamydospores fairly numerous, 9.0–21.0 × 7.5–12.0μ ---------- *Trametes americana*
2	1	2	1	9	1	2	2	4	2	2	---------- *Fomes officinalis*, *Poria asiatica*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
2	1	2	1	9	2	2	1	1	2	2	*Polyporus adustus*
2	1	2	1	9	2	2	1	1	2	3	*Polyporus adustus*
2	1	2	1	9	2	2	2	1	2	2	*Polyporus adustus* *Polyporus dichrous*
2	1	2	1	9	2	2	2	1	2	3	*Polyporus adustus*
2	1	2	1	9	2	2	2	2	1	1	*Fomes roseus*
2	1	2	1	9	2	2	2	2	1	2	Mat pale-pink; fruiting surface diffuse, granular to irregularly pored—*Fomes roseus*
											Mat white; fruit bodies distorted mushrooms with gills—*Pleurotus ostreatus*
											Mat white, slightly raised, cottony-woolly, frequently with strands originating at inoculum and extending across surface or around edge of plate and expanding in plumelike structure usually bearing pored fruit bodies—*Poria Vaillantii*
											Mat white, fruiting in minutely pored areas on surface—*Poria xantha*
2	1	2	1	9	2	2	2	2	2	2	Mat cottony-woolly, usually uniform in appearance; diameter on gallic acid agar 1.5–4.0 cm., on tannic acid agar trace to 3.0 cm.—*Fomes pinicola*
											Mat appressed, woolly-felty, with slightly raised tufts, arranged in more or less concentric lines, producing zonate appearance; no growth on gallic or tannic acid agars—*Pleurotus ostreatus*
											Mat all submerged or appressed or with some areas developing powdery to floccose or tufted mycelium; reverse in some isolates greenish-yellow; no growth or only a trace on gallic and tannic acid agars—*Polyporus dichrous*
											Mat white, slightly raised, cottony-woolly, frequently with strands originating at inoculum and extending across surface or around edge of plate and expanding in plumelike structures; good growth on gallic acid agar, no growth on tannic acid agar—*Poria Vaillantii*
											Mat raised in newest growth, cottony, then collapsed, leaving thin film on agar; good growth on gallic acid agar, no growth on tannic acid agar—*Poria xantha*
2	1	2	1	9	2	2	2	3	1	2	Mat at first downy, translucent, becoming woolly, opaque, mostly appressed but frequently with a zone of raised mycelium midway across colony; fruiting after five to six weeks over areas of newest growth, the pores broad; basidiospores cylindric, 10.8–13.5 × 3.6–4.5μ—*Trametes heteromorpha*
											Mat at first appressed, downy, soon developing zones in which mycelium is slightly raised, woolly, opaque, the surface becoming pebbled, and pored; basidiospores not found in six weeks old cultures—*Trametes sepium*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
2	1	2	1	9	2	2	2	3	1	2	Mat appressed, felty, soon pitted and corrugated to form irregularly pored surface, which finally extends over whole colony; basidiospores cylindric, 6.3–8.1 × 2.2–2.7μ ---------- *Trametes serialis*
											Mat at first appressed, downy to fine woolly, developing fine dots of more compact mycelium that finally coalesce to form a continuous felty to pellicular surface over older part, which finally becomes pored; basidiospores cylindric, 7.2–9.0 × 2.7–3.6μ ---------- *Trametes variiformis*
2	1	2	1	9	2	2	2	3	2	2	Mat cottony-woolly, usually uniform in appearance; diameter on gallic acid agar 1.5–4.0 cm., on tannic acid agar trace to 3.0 cm. ---- *Fomes pinicola*
											Mat white at first, developing patches of "barium yellow" and similar shades, slightly raised, silky, then cottony-woolly, with small strands radiating from inoculum over surface of mat and expanding in fanlike arrangement at margin, or with strands grown up sides of Petri dish and over cover; diameter on gallic acid agar 1.5–2.0 cm., no growth on tannic acid agar ---------- *Merulius lacrymans*
											Mat raised, cobwebby-cottony to plumose, becoming collapsed and appressed in older part; good growth on gallic acid agar, no growth on tannic acid agar ---------- *Polyporus subcartilagineus*
											(See immediately above) *Trametes heteromorpha* *Trametes sepium* *Trametes variiformis*
2	1	2	1	9	2	2	2	4	1	2	---------- *Trametes variiformis*
2	1	2	1	9	2	2	2	4	2	2	---------- *Polyporus fragilis* *Trametes variiformis*
2	1	2	2	1	2	2	2	2	1	2	---------- *Polyporus fibrillosus*
2	1	2	2	9	1	1	2	2	2	2	---------- *Polyporus sulphureus*
2	1	2	2	9	1	2	1	2	2	2	---------- *Trametes americana*
2	1	2	2	9	1	2	1	3	2	2	---------- *Trametes americana*
2	1	2	2	9	1	2	2	2	2	2	---------- *Polyporus sulphureus*
2	1	2	2	9	2	2	1	1	2	2	---------- *Peniophora gigantea*
2	1	2	2	9	2	2	1	2	2	2	---------- *Peniophora gigantea* *Trametes americana*
2	1	2	2	9	2	2	1	3	2	2	---------- *Trametes americana*
2	1	2	2	9	2	2	1	4	2	2	---------- *Merulius lacrymans*
2	1	2	2	9	2	2	2	2	2	1	---------- *Polyporus mollis*
2	1	2	2	9	2	2	2	2	2	2	---------- *Polyporus mollis*
2	1	2	3	9	1	2	2	2	2	2	---------- *Lentinus lepideus*
2	1	2	3	9	2	2	2	2	2	2	---------- *Lentinus Kauffmanii*
2	1	2	3	9	2	2	2	3	2	2	---------- *Lentinus Kauffmanii*
2	1	2	4	9	2	2	1	1	2	1	---------- *Coniophora puteana*
2	1	2	4	9	2	2	1	1	2	2	---------- *Coniophora puteana*
2	1	2	4	9	2	2	2	1	2	1	---------- *Coniophora puteana*
2	1	2	4	9	2	2	2	1	2	2	---------- *Coniophora puteana* *Poria rufa*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Continued*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
2	2	1	1	5	2	2	2	2	2	1	*Ganoderma oregonense*
2	2	1	1	5	2	2	2	2	2	2	Fiber hyphae numerous; widely distributed, but rarely encountered on coniferous trees *Ganoderma applanatum*
											Fiber hyphae lacking; limited to western coniferous trees *Ganoderma oregonense*
											Fiber hyphae numerous; limited to eastern coniferous trees *Ganoderma Tsugae*
2	2	1	1	5	2	2	2	2	2	3	*Ganoderma Tsugae*
2	2	1	1	5	2	2	2	4	2	2	*Ganoderma applanatum*
2	2	1	1	6	2	2	2	2	2	1	*Polyporus tuberaster*
2	2	1	1	6	2	2	2	2	2	2	*Collybia radicata*
2	2	1	1	6	2	2	2	3	2	1	*Polyporus tuberaster*
2	2	1	1	6	2	2	2	4	2	2	*Omphalia campanella*
2	2	1	1	9	1	2	2	2	1	2	*Polyporus cinnabarinus*
2	2	1	1	9	2	1	2	2	2	2	*Pholiota adiposa*
2	2	1	1	9	2	1	2	3	2	2	*Pholiota adiposa*
2	2	1	1	9	2	2	2	2	2	1	*Polyporus tuberaster*
2	2	1	1	9	2	2	2	2	2	2	*Collybia radicata*
2	2	1	1	9	2	2	2	3	2	1	*Polyporus tuberaster*
2	2	1	2	2	1	2	2	4	2	1	*Polyporus circinatus*
2	2	1	2	2	2	2	2	2	1	1	*Polyporus gilvus*
2	2	1	2	2	2	2	2	2	1	2	*Polyporus gilvus*
2	2	1	2	2	2	2	2	2	2	2	*Poria Weirii*
2	2	1	2	2	2	2	2	2	2	3	*Poria Weirii*
2	2	1	2	2	2	2	2	3	2	2	*Poria ferrugineo-fusca*
2	2	1	2	2	2	2	2	4	2	1	Setae numerous in some isolates, rare in others, 30.0–67.0 × 4.5–7.0μ; expansions on brown aerial hyphae up to 7.5μ diameter, occurring singly or in series *Fomes Pini*
											Setae rare or apparently lacking in some isolates, 52.0–60.0 × 7.5–9.0μ; globose swellings and chlamydosporelike bodies numerous, hyaline to brown *Polyporus circinatus*
											Setae or setal hyphae fairly numerous, 4.5–6.0μ diameter, up to 200μ long *Poria ferruginosa*
2	2	1	2	3	2	2	2	4	2	1	*Fomes nigrolimitatus*
2	2	1	2	5	2	2	2	4	2	1	*Armillaria mellea*
2	2	1	2	5	2	2	2	4	2	2	*Armillaria mellea*
2	2	1	2	6	2	2	2	2	2	2	*Hymenochaete tabacina*
2	2	1	2	6	2	2	2	4	2	1	*Poria tsugina*
2	2	1	2	7	1	2	2	4	2	1	*Polyporus circinatus*
2	2	1	2	7	2	2	2	4	2	1	*Fomes Pini* *Polyporus circinatus*
2	2	1	2	7	2	2	2	4	2	2	*Trametes tenuis*
2	2	1	2	9	2	1	2	1	2	2	*Fomes annosus*
2	2	1	2	9	2	1	2	4	2	2	*Fomes annosus*
2	2	1	2	9	2	2	2	1	2	1	*Hymenochaete corrugata*
2	2	1	2	9	2	2	2	1	2	2	*Hymenochaete corrugata*

KEY FOR THE IDENTIFICATION OF CULTURES OF WOOD-ROTTING FUNGI—*Concluded*

Host	Color	Reaction	Septation	Spec. structures	Chlamydospores	Conidia	Oidia	Growth rate	Fruiting	Reverse	
2	2	1	2	9	2	2	2	2	2	1	*Hymenochaete corrugata* *Polyporus gilvus*
2	2	1	2	9	2	2	2	2	2	2	*Hymenochaete corrugata* *Polyporus gilvus*
2	2	1	2	9	2	2	2	3	2	2	*Poria ferrea*
2	2	1	2	9	2	2	2	3	2	3	*Poria ferrea*
2	2	1	2	9	2	2	2	4	2	1	Mat "chamois", "raw sienna", "buckthorn brown", "cinnamon-brown", slightly raised, loosely arranged, cottony-woolly, thin enough to allow dark color of agar to show through, colors becoming duller with age, collapsed, thin felty; reverse sometimes green in narrow zone before brown color appears; bulbils usually present; limited to western conifers *Fomes nigrolimitatus*
											Mat with narrow white border, then "yellow ocher" to "snuff brown", "old gold", "Dresden brown", "Sudan brown", etc., the paler areas thin woolly-felty, the reddish brown areas velvety; no bulbils *Polyporus dryadeus*
											Mat white at margin, changing to "cream color", "honey yellow", "tawny-olive", the newest growth slightly raised, short cottony, becoming opaque woolly, tufted, with brittle crustose areas "Saccardo's umber", in color; no bulbils but interlocking brown hyphae forming pseudoparenchymatous layer usually present *Poria tsugina*
2	2	1	2	9	2	2	2	4	2	2	*Trametes tenuis*
2	2	2	1	9	1	2	1	2	1	2	*Lenzites trabea*
2	2	2	1	9	1	2	1	2	2	2	*Lenzites saepiaria*
2	2	2	1	9	1	2	1	3	2	2	*Lenzites saepiaria*
2	2	2	1	9	1	2	1	4	2	2	*Lenzites saepiaria*
2	2	2	1	9	2	1	2	2	2	2	*Polyporus guttulatus*
2	2	2	1	9	2	2	1	2	2	2	*Lenzites saepiaria*
2	2	2	1	9	2	2	1	3	2	2	*Lenzites saepiaria*
2	2	2	1	9	2	2	1	4	2	2	*Lenzites saepiaria*
2	2	2	1	9	2	2	2	3	2	2	*Merulius lacrymans*
2	2	2	2	9	1	2	2	1	2	1	*Polyporus Schweinitzii*
2	2	2	2	9	1	2	2	1	2	2	*Polyporus Schweinitzii*
2	2	2	2	9	1	2	2	2	2	1	*Polyporus Schweinitzii*
2	2	2	2	9	1	2	2	2	2	2	*Polyporus Schweinitzii*
2	2	2	2	9	2	2	1	4	2	2	*Merulius lacrymans*
2	2	2	2	9	2	2	2	1	2	1	*Polyporus Schweinitzii*
2	2	2	2	9	2	2	2	1	2	2	*Polyporus Schweinitzii*
2	2	2	2	9	2	2	2	2	2	1	*Polyporus mollis*
2	2	2	2	9	2	2	2	2	2	2	*Polyporus Schweinitzii* *Polyporus mollis* *Polyporus Schweinitzii*
2	2	2	3	9	1	2	2	4	2	1	*Stereum abietinum*
2	2	2	4	9	2	2	1	1	2	1	*Coniophora puteana*
2	2	2	4	9	2	2	1	1	2	2	*Coniophora puteana*
2	2	2	4	9	2	2	2	1	2	1	*Coniophora puteana*
2	2	2	4	9	2	2	2	1	2	2	*Coniophora puteana*

Descriptions of Cultures

Armillaria mellea Vahl ex Fries

KEY PATTERN: (1,2) 2 1 2 5 2 2 2 4 2 (1,2)

CULTURES EXAMINED:

CANADA.—New Brunswick: Copper Cliff, F2890. British Columbia: Cowichan Lake, on *Pseudotsuga taxifolia*, 8185; Vancouver, on *P. taxifolia*, 8559. UNITED STATES.—Washington: Northport, on *Larix* sp., F7100.

CULTURAL CHARACTERS: (Pl. I, Fig. 1; Pl. II, Figs. 1 to 3).

GROWTH CHARACTERS.—Growth very slow, radius 3.0–4.0 cm. in six weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mats of two types: (*a*) white (two weeks), the central part becoming "wood brown" (7.0YR 5.7/4.0) to "Hay's brown" (2.0YR3.5/2.0) (three weeks), raised, velvety to plushlike, with some radiating valleylike grooves; reverse unchanged or "snuff brown" (7.0YR3.9/3.5) below inoculum, with rhizomorphs numerous, short, branched, or completely lacking; (*b*) white, appressed, downy, zonate, with large areas "snuff brown" (7.0YR3.9/3.5), "burnt umber" (2.0YR2.5/2.5) (two weeks), and "carob brown" (2.0YR3.1/2.3) (four weeks), felty to crustose or lacquerlike, in part covered with whitish bloom and scattered erect tufts of pinkish-brown hyphae, reverse unchanged to "snuff brown" (7.0YR3.9/3.5) below colored areas, with branched rhizomorphs concolorous or white. Odor none. On gallic and tannic acid agars diffusion zones strong, no growth or only a trace on gallic acid agar, trace to 1.0 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 1.5–4.5μ diameter. *Aerial mycelium*: (*a*) hyphae as in advancing zone, frequently buffy-brown in older cultures; (*b*) hyphae in erect tufts buffy-brown, covered with minute hairlike projections. *Submerged mycelium*: (*a*) hyphae as in advancing zone; (*b*) cuticular cells, at first hyaline with contents staining in phloxine, then apparently empty, with walls buffy-brown, closely packed to form pseudoparenchymatous layer.

TYPE OF ROT: soft white butt and root rot of coniferous and broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Benton and Ehrlich (28), Campbell (39), Cartwright and Findlay (54, 56), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Edgecombe (69), Hamada (81), Reitsma (129).

Cultures of *Armillaria mellea* may be readily recognized on the basis of macroscopic appearance alone, their reddish-brown crustose areas, their rhizomorphs, and the frequent luminosity of young, actively-growing colonies providing a group of characters unique among the species studied. One of the key patterns coincides with that for *Fomes igniarius* var. *populinus*, but the distinctive wintergreen odor of this species readily separates it from *Armillaria mellea*.

Collybia radicata Relh. ex Fries

KEY PATTERN: (1,2) (1,2) 1 1 (6,9) 2 2 2 2 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Mt. Burnett, F3461. UNITED STATES.—F2934.

CULTURAL CHARACTERS: (Pl. I, Fig. 2; Pl. II, Figs. 4 to 6).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in four weeks. Advancing zone even, appressed in narrow zone, with fibers widely separated, making it difficult to see limit of growth. Mat white and remaining so, or after two to six weeks becoming "buffy brown" (9 0YR4.6/3.5) to "olive-brown" (8.0YR3.8/2.0) in small areas at edge and in lines traversing the white mat, raised, downy to cottony to cottony-woolly and somewhat spongy, later collapsed, felty, the colored areas crustose. Reverse unchanged, with conspicuous

thonglike strands of compact mycelium grown from surface down through the agar. Odor strong, penetrating. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, diameter 1.5–2.0 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–3.0 (–6.0)μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently branched; (*b*) crustose areas and thonglike strands composed of "intermeshing hyphae which form a homogeneous tissue without interhyphal space", that is, a pseudoparenchymatous layer. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of roots, presumably of broad-leaved and coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (40).

Cultures of this species that develop no pseudoparenchymatous layer and so remain white have a key pattern identical with those of several other species, all of which differ from *Collybia radicata* in the occurrence of numerous fiber hyphae. Cultures of *Collybia radicata* that form a pseudoparenchymatous layer and become colored have a key pattern like those for *Daedalea confragosa*, *Polyporus brumalis*, and *P. tuberaster*. The thonglike strands extending from the surface down through the agar occur only in *Collybia radicata*, and serve to distinguish this species from the other similar species.

Collybia velutipes Curt. ex Fries

KEY PATTERN: 1 2 2 1 (8,9) 2 2 1 2 2 2

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, on *Tilia* sp., F1598. GERMANY.—Eberswalde, on broad-leaved tree, F1294.

CULTURAL CHARACTERS: (Pl. I, Fig. 3; Pl. II, Figs. 7 to 9).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white (one week), the older part becoming "colonial buff" (6.0Y8.5/5.5) to "chamois" (2.0Y7.5/5.8) (two weeks), to "honey yellow" (2.0Y6.7/6.2) and "Saccardo's umber" (9.0YR3.8/3.5) (three to six weeks), the color gradually extending over colony but always mixed with white so that color appears pale, at first slightly raised, cottony with farinaceous surface, later appressed, thin woolly with minute tufts, approaching crustose in brown areas around inoculum. Reverse unchanged. Odor strong, suggesting iodoform, in cultures four weeks old, becoming fainter with age. On gallic and tannic acid agars no diffusion zones, no growth on either medium. (Davidson, Campbell, and Blaisdell report a very weak positive reaction on gallic acid agar.)

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) oidia numerous, produced by the fragmentation of hyphae with simple septa formed as branches from nodose-septate hyphae, 2.2–3.0μ diameter, of variable lengths; (*c*) lactiferous cells observed in F1598, deeply stained in phloxine and conspicuous in mounts, frequently with small projections, up to 9.0–15.0μ diameter. *Submerged mycelium:* (*a*) hyphae as in advancing zone, up to 4.5μ diameter; (*b*) lactiferous cells as in aerial mycelium.

TYPE OF ROT: white spongy rot of sapwood of living broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Brodie (36), Davidson, Campbell, and Blaisdell (64), Edgecombe (69), Heldmaier (82), Humphrey and Siggers (92), Zattler (152).

The restriction of oidium formation to hyphae with simple septa formed as branches from nodose-septate hyphae differentiates cultures of *Collybia velutipes* from those of *Lenzites saepiaria*, in which the nodose-septate hyphae undergo fragmentation to form oidia, and from *Merulius lacrymans*, in which

the whole mycelium reverts to a haploid condition, characterized by the presence of simple septa in all hyphae, and numerous oidia.

Coniophora puteana (Schum. ex Fries) Karst.

KEY PATTERN: (1,2) (1,2) 2 4 9 2 2 (1,2) 1 2 (1,2)

CULTURES EXAMINED:

CANADA.—Quebec: Champlain county, on *Picea mariana*, 10273, 10274; Eagle Depot, on *Abies balsamea*, 8546; Lac Humqui, on *A. balsamea*, F309. GERMANY.—9779.

CULTURAL CHARACTERS: (Pl. I, Fig. 4; Pl. II, Figs. 10 to 14).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white and remaining so or with tinges of "cartridge buff" (3.0Y8.5/2.2), "colonial buff" (6.0Y8.5/5.5), and "deep colonial buff" (4.0Y7.7/5.5), the color deepest in newest growth, which is raised, cottony, tufted, the older part appressed, downy, with prominent radiating fibers or uniformly felty, frequently grown against sides of Petri dish and across lid. Reverse unchanged (two weeks) to "chamois" (2.0Y7.5/5.8), "honey yellow" (2.0Y6.7/6.2), and "cinnamon-brown" (5.0YR3.0/3.0). Odor strong, unpleasant. On gallic and tannic acid agars no diffusion zones, diameter 5.5–7.0 cm. on gallic acid agar, 1.5–2.0 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* (*a*) main hyphae hyaline, occasionally with a single clamp connection at a septum, usually with multiple clamp connections, frequently each producing a branch so that a whorl of branches is formed at a node, 6.0–12.0μ diameter; (*b*) branches from main hyphae usually narrower, with inconspicuous simple septa, frequently branched, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) broad hyphae as in advancing zone, occasionally up to 15.0μ diameter, observed only near edge of colony, soon empty and collapsed; (*b*) hyaline hyphae with simple septa as in advancing zone; (*c*) brown hyphae with simple septa, branched, with numerous knoblike or bulbous protuberances along walls, 2.2–4.5μ diameter; (*d*) oidia observed in some isolates, especially in tufts of mycelium at edge of Petri dish, 2.2–6.0μ diameter, variable in length. *Submerged mycelium:* (Agar almost liquefied below colony.) (*a*) hyaline hyphae with simple septa as in aerial mycelium; (*b*) crystals numerous, octahedral.

TYPE OF ROT: brown cubical rot of coniferous and broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright and Findlay (51, 52, 54, 56), Davidson and Campbell (63), Davidson, Campbell, and Blaisdell (64), Humphrey and Siggers (92), Kemper (95).

With four diagnostic characters that may vary, *Coniophora puteana* appears no less than 16 times in the key. The conspicuous multiple clamp connections and characteristic whorls of branches in the advancing zone separate it readily from the only other species, *Poria rufa*, which has a key pattern identical with any of those for *Coniophora puteana*.

Daedalea confragosa Bolt. ex Fries

KEY PATTERN: 1 2 1 1 (6,9) 2 2 2 2 2 (1,2)

CULTURES EXAMINED:

CANADA.—Quebec: Chelsea, on *Betula papyrifera*, 9210; Meach Lake, on *Fagus grandifolia*, F1577. Ontario: Constance Bay, on *Betula* sp., F5213; Ottawa, on *Acer* sp., 8997.

CULTURAL CHARACTERS: (Pl. I, Fig. 5; Pl. II, Figs. 15 to 17).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three weeks. Advancing zone even, hyaline and appressed in zone 1–2 mm. wide. Mat white, with patches of "pinkish cinnamon" (6.0YR6.5/5.5), "cinnamon" (5.0YR5.8/6.0), and "snuff brown"

(7.0YR3.9/3.5) (two to three weeks), to "bister" (4.5YR3.0/3.0) (four weeks), the newer growth downy to fine woolly and minutely lacunose, becoming felty to chamoislike, and crustose in colored areas. Reverse unchanged or "snuff brown" (7.0YR3.9/3.5) to "antique brown" (8.0YR4.2/2.5) in irregular patches. Odor in some isolates fairly strong at two to three weeks of age, suggesting pepper, disappearing with age. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, trace to 1.5 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, with walls thick and refractive, hyaline or yellow in crustose areas, the lumina narrow or apparently lacking, occasionally branched, aseptate, curving and interwoven, 1.5–3.0μ diameter; (*c*) hyphae from skinlike areas nodose-septate, with numerous short branches or projections, compactly arranged and interwoven with fiber hyphae to produce pseudoparenchymatous areas. *Submerged mycelium:* (*a*) hyphae as in advancing zone, frequently branched; (*b*) crystals short, needlelike.

TYPE OF ROT: white mottled rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67).

Cultures of *Daedalea confragosa* may fail to develop a definite pseudoparenchymatous layer, in which case the key pattern will be identical with those for *Fomes scutellatus* and *Collybia radicata*. In the key, mention is made of the macroscopic appearance of the cultures, but in addition it may be noted that *Fomes scutellatus* is usually limited to *Alnus* spp., and that fiber hyphae are lacking in cultures of *Collybia radicata* and numerous in cultures of the other species. Cultures of *Daedalea confragosa* that form a pseudoparenchymatous layer key also to *Polyporus tuberaster*, *P. brumalis*, and *Collybia radicata*. *Polyporus tuberaster* occurs very rarely, being known from Canada from only a few localities in Manitoba and Saskatchewan, and never in association with decay. Cultures of *Daedalea confragosa* differ from those of *Polyporus brumalis* in the extent of the colored areas on the surface, and from cultures of *Collybia radicata* in the presence of fiber hyphae, which are lacking in the latter species.

Daedalea quercina L. ex Fries

KEY PATTERN: 1 1 2 1 9 1 2 2 2 (1,2) 2

CULTURES EXAMINED:

CANADA.—Ontario: Morton, on *Quercus* sp., F2278; Ottawa, on *Quercus* sp., F676. UNITED STATES.—North Carolina: F2158.

CULTURAL CHARACTERS: (Pl. I, Fig. 6; Pl. II, Figs. 18 to 24).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in four weeks. Advancing zone even, fibers appressed, closely arranged, radiating. Mat white, newest growth woolly floccose, becoming appressed, woolly-felty, with slightly raised reticulations, producing a "towelled" (Cartwright and Findlay) effect, frequently fruiting over raised tufts after five to six weeks. Reverse unchanged. Odor strong at three to four weeks, fruity. On gallic and tannic acid agars no diffusion zones, diameters 2.0–3.0 cm. on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched at and between septa, with occasional branches directed backward from posterior part of clamp connection, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently with walls irregularly thickened and lumina relatively narrow, up to 6.0μ diameter; (*b*) fiber hyphae numerous in cultures five to six weeks old, with walls thick and refractive, lumina narrow or apparently lacking, occasionally branched, aseptate, 2.2–3.0μ diameter; (*c*) chlamydospores numerous, broadly ovoid, with thick walls, 12.0–18.0μ diameter. *Fruit body:* (*a*) thin-walled hyphae and (*b*) fiber hyphae as in aerial mycelium; (*c*) basidia 4.5–6.0μ diameter, bearing four sterigmata up to 6.0μ long; (*d*) basidiospores hyaline, even, oblong-

ellipsoid to cylindric, slightly flattened on one side, 6.0–8.0 × 2.5–3.0μ. *Submerged mycelium:* (*a*) nodose-septate hyphae up to 8.0μ diameter and (*b*) chlamydospores as in aerial mycelium; (*c*) crystals numerous, octahedral.

TYPE OF ROT: brown cubical rot of broad-leaved trees, especially *Quercus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (51, 52, 53, 56), Davidson, Campbell, and Blaisdell (64), Humphrey and Siggers (92), Walek-Czernecka (150).

Cultures of *Daedalea quercina* have key patterns identical with those for a number of other species. In the inserted descriptive keys are noted differences in color and topography of the mats, and in chlamydospores and basidiospores, which should serve to distinguish the different species. Cultures of *Daedalea quercina* are similar to those of *Poria monticola* but the early formation of typical foliose fruit bodies by most cultures of the latter species makes its cultures readily recognizable.

Daedalea unicolor (Bull.) Fries

KEY PATTERN: (1,2) 1 1 1 9 2 2 2 1 2 3

CULTURES EXAMINED:

CANADA.—Quebec: Iberville, F8022; Ile Jésus, on *Betula papyrifera*, 10202. Ontario: Lake of Bays district, on *B. papyrifera*, 10196.

CULTURAL CHARACTERS: (Pl. I, Fig. 7; Pl. II, Figs. 25 and 26).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white, raised, loosely arranged, cottony-floccose, becoming collapsed, cottony-woolly in older part, with irregular thickenings giving lacunose effect, grown to top of Petri dish and extending over inner surface of lid in thick layer. Reverse unchanged for three to four weeks, then bleached. Odor strong, like *Psalliota campestris*. On gallic and tannic acid agars diffusion zones moderately strong, no growth on gallic acid agar, diameter 2.0–2.5 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, with walls thick and refractive, lumina apparently lacking, aseptate, rarely branched, 1.5–2.2μ diameter. *Submerged mycelium:* hyphae as in advancing zone, up to 6.0μ diameter.

TYPE OF ROT: white rot of broad-leaved or, rarely, coniferous trees, frequently found decaying sapwood and causing cankers of living trees (Campbell (43)).

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Humphrey and Siggers (92).

The species having the same key patterns as *Daedalea unicolor* are difficult to separate in culture. The lacunose surface and growth of mycelium across the lid of the Petri dish in cultures of *D. unicolor* may be sufficiently distinctive to separate it from the other species in the group.

Echinodontium tinctorium Ell. and Ev.

KEY PATTERN: 2 1 1 1 (1,9) 1 2 2 4 2 1

CULTURES EXAMINED:

CANADA.—British Columbia: Aleza Lake, on *Abies* sp., 16578; Queen Charlotte Islands, on coniferous tree, 16049; Trinity Valley, on *Tsuga*

heterophylla, 8740. UNITED STATES.—California: Strassburg, on *Abies concolor*, F620. Washington: Spirit Mountain, on *A. grandis*, F1157; Northport, on *Tsuga heterophylla*, F7423.

CULTURAL CHARACTERS: (Pl. I, Fig. 8; Pl. II, Figs. 27 to 30).

GROWTH CHARACTERS.—Growth very slow, radius 2.5–5.0 cm. in six weeks. Advancing zone even, appressed or with raised cottony mycelium extending to limit of growth. Mat white, appressed, farinaceous to felty, more or less completely overgrown with long tangled cottony mycelium, especially abundant against side of Petri dish above inoculum. Reverse "sayal brown" (7.0YR5.0/5.5) to "snuff brown" (7.0YR3.9/3.5), the colored diffusion zone frequently extending beyond edge of colony. Odor strong, disagreeable at first, suggestive of almonds at six weeks. On gallic acid agar diffusion zone strong, on tannic acid agar moderately strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently with yellow to brown oily contents, with occasional swellings up to 7.5μ diameter; (*b*) chlamydospores fairly numerous, with walls thin or slightly thickened, at first hyaline with contents stained in phloxine, later empty, broadly ovoid, 7.5–10.5 × 6.5–9.0μ; (*c*) cystidia fairly numerous in most isolates, clavate or elongate-cylindric, frequently with single or moniliform swellings, with walls thick and lumina evident only in swollen parts, partially incrusted, up to 13.5μ diameter. *Submerged mycelium:* (*a*) hyphae and (*b*) chlamydospores as in aerial mycelium.

TYPE OF ROT: brown stringy heart rot of living coniferous trees in western Canada and United States.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

Cystidia occur in cultures of *Echinodontium tinctorium*, but their appearance may be delayed in some isolates beyond the six weeks' period during which examinations are made. Therefore two key patterns are given for the species, one with cystidia, one without special structures, but neither of these coincides with the key pattern for any other species.

Favolus alveolaris (DC. ex Fries) Quél.

KEY PATTERN: 1 1 1 1 9 2 2 2 3 2 (2,3)

CULTURES EXAMINED:

CANADA.—Quebec: Chelsea, on *Ulmus americana*, F628. Ontario: Ottawa, on branch of broad-leaved tree, F1338.

CULTURAL CHARACTERS: (Pl. I, Fig. 9; Pl. II, Figs. 31 and 32).

GROWTH CHARACTERS.—Growth slow, plates covered in six weeks. Advancing zone even or somewhat bayed, hyaline and appressed in narrow zone. Mat white, appressed, fine woolly or subfelty. Reverse unchanged or bleached after three to four weeks. Odor slight. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, diameter up to 1.0 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae nodose-septate, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, with walls thick and refractive, lumina apparently lacking, aseptate, branched, curving and interwoven, 1.0–1.5μ diameter. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

Cultures of *Favolus alveolaris* that do not bleach the agar have a key pattern identical with that of *Fomes Ellisianus*. The latter is specific to *Shepherdia*

argentea, which fact will probably serve to differentiate between these two species.

Fomes annosus (Fries) Cooke

KEY PATTERN: (1,2) (1,2) 1 2 9 2 1 2 (1,4) 2 2

CULTURES EXAMINED:

CANADA.—British Columbia: Oyster River, on log, 8273, on *Pseudotsuga taxifolia*, 8429, on *Tsuga heterophylla*, 8415; Queen Charlotte Islands, on *Picea sitchensis*, 10735; Royston, on rotted log, 8239. CZECHOSLOVAKIA.—F8061. ENGLAND.—Norfolk, on *Larix* sp., 9260. GERMANY.—Eberswalde, on conifer, F1288. HOLLAND.—Baarn, F6326, F6327.

CULTURAL CHARACTERS: (Pl. I, Fig. 10; Pl. II, Figs. 33 to 35).

GROWTH CHARACTERS.—Cultures of two types: (*a*) growth rapid, plates covered in two weeks. Advancing zone even, hyaline, appressed. Mat white, with patches of "cream-buff" (3.0Y8.3/4.5), "chamois" (2.0Y7.5/5.8), and "honey yellow" (2.0Y6.7/6.2) in some isolates after two to four weeks, the newer growth slightly raised, sparse downy to floccose-cottony, becoming collapsed and appressed, thin felty, with farinaceous surface; (*b*) growth very slow, radius 3.0 cm. or less in six weeks. Advancing zone even or bayed, felty aerial mycelium uniform to limit of growth. Mat white, appressed, felty with somewhat farinaceous surface. Reverse unchanged or with zones of "honey yellow" (2.0Y6.7/6.2). Odor none in some isolates, faintly of lemon in others, strong and disagreeable in the remainder. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae with simple septa or rare clamp connections, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, 2.2–6.0μ diameter; (*b*) conidiophores numerous in most isolates, consisting of erect stalks, simple or branched, 4.5–7.5μ diameter, swollen to form globose heads, 7.5–22.0μ diameter, bearing conidia on slender pointed sterigmata over the distal end of the head and occasionally along the stalk; (*c*) conidia very numerous, hyaline, even, subglobose to ovoid, apiculate, 4.5–7.5 (−10.5) × 3.0–6.0μ. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white pocket rot of coniferous or, rarely, broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42), Cartwright and Findlay (51, 54, 56), Davidson, Campbell, and Blaisdell (64), Humphrey and Siggers (92), Roll-Hansen (135).

In *Fomes annosus* there is the possibility of variation in three of the characters used in the identification of cultures, which results in this species appearing eight times in the key. In spite of this its cultural characters are unique and it is not to be confused with any other species included in the key. One of the variations reported is that in growth rate, some isolates growing rapidly, others very slowly, and some growing rapidly at one time of planting, slowly at another. It seems probable that the rapid growth is more usual and that the slow growth is the result of some local adverse condition. An additional variation not considered in the key is the possible presence of clamp connections. They were observed in a few isolates, but they occurred only rarely, and always in hyphae in which most of the septa were simple. Roll-Hansen (135) has reported a similar observation.

Fomes conchatus (Pers. ex Fries) Gill.

KEY PATTERN: 1 2 1 2 (7,9) 2 2 2 4 2 1

CULTURES EXAMINED:

CANADA.—Quebec: Kingsmere, on log, 9219; Montreal, on log of broad-leaved tree, F2571; Pointe Platon, on *Crataegus* sp., 10159. Ontario: Lake Timagami, on fallen log, F1403; Ottawa, on stump, F1381. UNITED STATES.—on *Fraxinus americana*, F639.

CULTURAL CHARACTERS: (Pl. I, Fig. 11; Pl. II, Figs. 36 to 38).

GROWTH CHARACTERS.—Growth very slow, radius 4.5–7.5 cm. in six weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mats of three types: (*a*) white to "mustard yellow" (2.0Y7.8/7.5), "primuline yellow" (1.5Y7.5/9.5), "chamois" (2.0Y 7.5/5.8), and "honey yellow" (2.0Y6.7/6.2) (two weeks) to "deep colonial buff" (4.0Y7.7/5.5) and "olive-ocher" (3.0Y6.8/6.5) (three weeks), with little subsequent change in color, slightly raised, cottony, so thin that color of darker agar shows through; (*b*) white to "cream-buff" (3.0Y8.3/4.5) and "chamois" (2.0Y7.5/5.8), raised, thick woolly, opaque; (*c*) sectored, with varying amounts of opaque woolly mycelium as in (*b*) and thin mycelium as in (*a*). Reverse unchanged below newer growth, then "buckthorn brown" (8.0YR4.8/6.5), "sayal brown" (7.0YR5.0/5.5) to "cinnamon-brown" (5.0YR3.0/3.0) and "snuff brown" (7.0YR 3.9/3.5), with greenish tinge approaching "citrine-drab" (5.5Y5.0/2.8) sometimes observed. Odor none. On gallic and tannic acid agars diffusion zones weak to strong, no growth on gallic acid agar, trace to 2.0 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) colored hyphae, with greenish-yellow walls and contents hyaline or dark brown, septate, branched, 2.2–6.0μ diameter. *Submerged mycelium:* (*a*) hyphae hyaline to brown, frequently branched and septate, 3.0–7.5μ diameter; (*b*) swellings on hyphae, usually terminal, up to 20μ diameter, numerous in some isolates, rare or apparently lacking in others.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42), Davidson, Campbell, and Blaisdell (64).

Cultures of *Fomes conchatus* with swollen cells have a key pattern identical with that for *F. Pini*, but the swellings on the hyphae of the latter species are distinctive, usually occurring in series in brown thick-walled aerial hyphae, while those of *F. conchatus* are single, usually terminal, and restricted to submerged mycelium. Cultures without these special structures coincide in the key with a number of other species, which must be separated on color and topographical differences that cannot be incorporated in a numerical key. Therefore a descriptive key to this group has been inserted.

Fomes connatus (Weinm.) Gill.

KEY PATTERN: 1 1 1 2 (7,9) 2 2 2 4 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Chelsea, on *Acer* sp., 10253; on broad-leaved tree, 10254. UNITED STATES.—Massachusetts: Harvard Forest, on *Ulmus* sp., F7990.

CULTURAL CHARACTERS: (Pl. I, Fig. 12; Pl. II, Figs. 39 and 40).

GROWTH CHARACTERS.—Growth very slow, radius 7.0 cm. or less in six weeks. Advancing zone even, appressed, hyaline. Mat white, at first limited to cottony ball over inoculum, gradually with appressed growth on agar, more or less completely covered with long, tangled, cottony mycelium. Reverse unchanged. On gallic and tannic acid agars diffusion zones weak, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, frequently branched, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae rare. *Submerged mycelium:* thin-walled hyphae as in advancing zone.

TYPE OF ROT: soft white rot of broad-leaved trees, especially *Acer* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (41), Davidson, Campbell, and Blaisdell (64).

The key patterns for *Fomes connatus* coincide with those for *Trametes tenuis*, but the latter species, while white at first, invariably develops scattered yellow to brown areas, and its appressed farinaceous to thin felty mat is completely unlike the long tangled cottony growth of *Fomes connatus*.

Fomes Ellisianus Anderson

KEY PATTERN: 1 1 1 1 9 2 2 2 (2,3) 2 2

CULTURES EXAMINED:

CANADA.—Saskatchewan: Saskatoon, on *Shepherdia argentea*, F7364, F7520.

CULTURAL CHARACTERS: (Pl. I, Fig. 13; Pl. II, Figs. 41 to 43).

GROWTH CHARACTERS.—Growth moderately slow to slow, plates covered in four to six weeks. Advancing zone even, hyaline and appressed for short distance, or with aerial mycelium uniform to limit of growth. Mat white, with "cream-buff" (3.0Y8.3/4.5) tinge over inoculum after four to six weeks, appressed, downy, becoming slightly more compact woolly around inoculum. Reverse unchanged or slightly darker. Odor none. On gallic and tannic acid agars diffusion zones weak to moderately strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently septate and branched, 1.5–3.0μ diameter; (*b*) fiber hyphae with walls slightly thickened, lumina fairly broad but apparently empty, aseptate, branched, 2.2–4.5μ diameter, rare to fairly numerous. *Submerged mycelium:* (*a*) nodose-septate hyphae as described above; (*b*) crystals numerous, needlelike or platelike.

TYPE OF ROT: white rot of *Shepherdia argentea*.

DESCRIPTIONS OF CULTURAL CHARACTERS: Baxter (8).

Fomes Ellisianus, known only from *Shepherdia argentea*, is considered by some students to be a form of *Fomes fraxinophilus*, which is usually confined to *Fraxinus* spp. Thus Baxter (8), as a result of comparative studies of the fruit bodies, the types of decays they caused, and the cultural characters of the two fungi, concluded that "they must be considered as a single species. *Fomes Ellisianus* Anderson is considered a form of *Fomes fraxinophilus* Pk." In the present study the presence of chlamydospores and early production of fruiting surfaces in culture served to distinguish *F. fraxinophilus* from *F. Ellisianus*, which lacks these characters. Pairing tests showed both species to be heterothallic, and of the tetrapolar type of interfertility. When monosporous mycelia from one collection of *F. fraxinophilus* were paired with those from another collection of the same species, mycelia bearing clamp connections were produced in every pairing, but complete lack of fertility was found when monosporous mycelia of *F. fraxinophilus* were paired with those of *F. Ellisianus*. This is a further indication that these constitute two distinct species.

Fomes Ellisianus falls with other species in the key, but its specificity to *Shepherdia argentea* is probably sufficient to separate it from them.

Fomes Everhartii (Ell. and Gall.) von Schrenk

KEY PATTERN: 1 2 1 2 9 2 2 2 (3,4) 2 1

CULTURES EXAMINED:

CANADA.—Quebec: Iberville, on *Fagus grandifolia*, F3580. UNITED STATES.—Michigan: Atlanta, on *Quercus velutina*, F2336. Locality and host not known, F3044.

CULTURAL CHARACTERS: (Pl. I, Fig. 14; Pl. II, Figs. 44 to 46).

GROWTH CHARACTERS.—Growth slow to very slow, plates covered in five to seven weeks. Advancing zone even, hyaline to white, aerial mycelium extending to limit of growth. Mat white to "baryta yellow" (4.0Y8.8/7.0), "light cadmium" (2.0Y7.8/9.5), and "yellow ocher" (10.0YR6.8/9.0) (one to four weeks), erect, silky-cottony, the fibers straight and 'combed' in appearance, zonate, so thin as to allow dark color of agar to show through, "often with a greenish-yellow sheen", after four or five weeks developing opaque, azonate areas more or less extensive, "cream-buff" (3.0Y8.3/4.5), "chamois" (2.0Y7.5/5.8), and "honey-yellow" (2.0Y6.7/6.2) in color. Reverse "buckthorn brown" (8.0YR4.8/6.5), "cinnamon-brown" (5.0YR3.0/3.0), and "mummy brown" (7.5YR2.5/2.3), somewhat zonate. Odor none. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 2.2-4.5 (-6.0)μ diameter. *Aerial mycelium:* hyphae as in advancing zone but with walls hyaline to brown, sometimes with dense dark brown contents, branched, frequently septate, 2.2–6.0μ diameter, occasionally compacted into small bulbil-like masses. *Submerged mycelium:* hyphae as in aerial mycelium.

TYPE OF ROT: "soft white or yellow flaky heart rot" of broad-leaved trees, usually *Quercus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Baxter (7), Campbell (42), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Humphrey and Siggers (92).

From the key it will be observed that a number of species have key patterns identical with those for *Fomes Everhartii*. When once it has become familiar, the appearance of the mat composed of straight silky 'combed' fibers with a greenish-yellow sheen over the darker brown agar is sufficiently characteristic to separate it from other species.

Fomes fomentarius (L. ex Fries) Kickx

KEY PATTERN: 1 2 1 1 (5,9) 2 2 2 1 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Kingsmere, on *Betula lutea*, 9214; Lac Clair, on *Betula* sp., 11599. SCOTLAND.—Pitlochry, on *Betula* sp., F8038, F8039.

CULTURAL CHARACTERS: (Pl. I, Fig. 15; Pl. II, Figs. 47 and 48).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, with aerial mycelium uniform to limit of growth. Mat white with tinge of "cream-buff" (3.0Y8.3/4.5) and "chamois" (2.0Y7.5/5.8) (one week), to "light pinkish cinnamon" (7.0YR7.5/4.5), "sayal brown" (7.0YR5.0/5.5), and "cinnamon-brown" (5.0YR3.0/3.0) (two weeks), with little subsequent change in color but extension in size of colored areas, at first slightly raised, short cottony, then appressed, felty to chamoislike in colored areas, with some raised white woolly plateaus. Reverse unchanged. Odor none. On gallic and tannic acid agars diffusion zones moderately strong to strong, no growth on gallic acid agar, 1.0–2.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–3.0(–4.5)μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous,

with walls thick and refractive, hyaline to buffy-brown, lumina narrow but evident, occasionally branched, aseptate, 1.5–3.0μ diameter, closely interwoven in skinlike areas; (*c*) cuticular cells, closely packed and interwoven with fiber hyphae in pseudoparenchymatous layer, observed in only two isolates. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white mottled rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Campbell (42), Cartwright and Findlay (55, 56), Davidson, Campbell, and Blaisdell (64), Fritz (74), Hilborn (83), Macdonald (102), Meyer (105).

In most isolates the tough chamoislike areas were composed of interwoven fiber hyphae only, but two cultures showed cuticular cells present in these areas, closely intermingled with the fiber hyphae. This character brings *Fomes fomentarius* close to the *Ganoderma* species, but the more rapid rate of growth of *Fomes fomentarius* separates it from these and other species in the key.

Fomes fraxineus (Bull. ex Fries) Cooke

KEY PATTERN: 1 1 1 1 (5,9) 1 2 2 2 (1,2) 2

CULTURES EXAMINED:

CANADA.—Quebec: Montreal, on *Ulmus* sp., F7519. UNITED STATES.—Virginia: F2161. Locality not known, on *Fraxinus* sp., F2022.

CULTURAL CHARACTERS: (Pl. III, Fig. 1; Pl. IV, Figs. 1 to 6).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, hyaline, appressed, silky. Mat white, cottony near margin, becoming felty and irregularly thickened, usually 'corroded' in appearance, sometimes with drops of exudate over surface, fruiting in some isolates after three to four weeks in organized pored areas or in inconspicuous groups of basidia scattered over surface. Reverse unchanged. Odor none. On gallic and tannic acid agars diffusion zones weak to moderately strong, no growth on gallic acid agar, trace to 1.5 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae nodose-septate, 1.5–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, walls thick, lumina narrow or apparently lacking, branched, aseptate, 1.5–4.5μ diameter; (*c*) chlamydospores numerous, terminal and intercalary, globose to ovoid with walls noticeably thick and often appearing sculptured, 10.5–16.5 × 7.5–12.0μ; (*d*) hyphae with tips branched dichotomously in staghorn or coralloid effect, observed in some isolates; (*e*) cuticular cells, hyaline, empty, forming a thin pseudoparenchymatous layer, observed in F7519 only. *Fruit body:* (*a*) basidia 7.5–10.5μ diameter, each bearing four spores; (*b*) basidiospores hyaline, even, subglobose or broadly ovoid, apiculate, with conspicuous oil drop, 5.4–6.0μ diameter, observed in large numbers in old cultures, apparently empty. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as described above.

TYPE OF ROT: white rot of broad-leaved trees, especially *Fraxinus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Baxter (6), Campbell (42), Cartwright and Findlay (51, 55, 56), Davidson, Campbell and Blaisdell (64), Montgomery (107).

Cultures of *Fomes fraxineus* that form cuticular cells fall alone in the key, but the more numerous isolates lacking these have key patterns identical with those for several other species. The inserted descriptive keys mention topographical and microscopic differences that should make separation possible. The chlamydospores of *Fomes fraxineus*, with thick sculptured walls, are distinctive.

Fomes fraxinophilus (Peck) Sacc.

KEY PATTERN: 1 1 1 1 9 1 2 2 2 1 2

CULTURES EXAMINED:

CANADA.—Quebec: Chelsea, on *Fraxinus americana*, F632. UNITED STATES.—Indiana: Greensfork, on *Fraxinus americana*, F1929. Michigan: Ann Arbor, on *F. americana*, F1931. New York: Newburgh, on *F. americana*, F1930. Locality and host unknown, F1932.

CULTURAL CHARACTERS: (Pl. III, Fig. 2; Pl. IV, Figs. 7 to 11).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, hyaline, appressed in narrow zone. Mat white, downy near margin, becoming compact felty around inoculum (one week), forming a uniform pellicle like soft chamois, which peels from agar readily (two weeks), with areas of raised velvety overgrowth, frequently along radii, usually bearing well-organized, poroid, waxy, fruiting surfaces (three to four weeks). Reverse unchanged to "pinkish buff" (9.0YR7.3/4.5). Odor none. On gallic and tannic acid agars diffusion zones moderately strong, no growth on gallic acid agar, 2.0–3.5 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae nodose-septate, frequently branched, with numerous anastomoses, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae with thick walls, lumina narrow or apparently lacking, frequently branched and closely interwoven, 2.0–3.0μ diameter; (*c*) basidiospores (from spore deposit) hyaline, even, ovoid, frequently truncate, walls fairly thick and refractive, 6.0–7.5 × 4.5–6.0μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores few to numerous, terminal and intercalary, ovoid to elongate, fairly thin-walled, 9.0–18.0 × 6.0–9.0μ; (*c*) crystals numerous, needlelike.

TYPE OF ROT: white mottled rot of broad-leaved trees, usually *Fraxinus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Baxter (8), Campbell (42), Davidson, Campbell, and Blaisdell (64).

Cultures of *Fomes fraxinophilus* are distinguished from other species having an identical key pattern by the texture of the mat, the raised pored fruiting surfaces, which are frequently radically elongated, and the characteristic truncate spores. Secondary spores such as were described by Campbell (42) were not observed in the isolates studied. A note on the differences between cultures of *F. fraxinophilus* and *F. Ellisianus* is included under the latter species.

Fomes fulvus (Scop.) Gill.

Fomes pomaceus (Pers.) Lloyd

KEY PATTERN: 1 2 1 2 9 2 2 2 2 2 (1,2)

CULTURES EXAMINED:

Received from Centraalbureau voor Schimmelcultures, Baarn, Holland, F2283, F7310.

CULTURAL CHARACTERS: (Pl. III, Fig. 3; Pl. IV, Figs. 12 to 15).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in four weeks. Advancing zone even, white, raised woolly mycelium extending to limit of growth. Mat with conspicuous white border, then "cream-buff" (3.0Y8.3/4.5) to "chamois" (2.0Y7.5/5.8) (one week), to "honey yellow" (2.0Y6.7/6.2) (two weeks), to "tawny-olive" (8.0YR4.8/5.8) (four weeks), raised, thick woolly, 'nodulose' or 'lacunose', peeling readily from agar. Reverse unchanged or with scattered areas of "burnt sienna" (2.0YR3.2/7.0) after four weeks. Odor fragrant. On gallic and tannic acid agars diffusion zones moderately strong, no growth on gallic acid agar, trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with inconspicuous simple septa, frequently branched, 1.5–4.5μ diameter. *Aerial mycelium* (preparation turns red-brown in potassium hydroxide): (*a*) hyphae as in advancing zone; (*b*) colored hyphae, with walls slightly thickened and buffy-brown, with few inconspicuous simple septa, rarely branched, 1.5–2.2μ diameter, with long tapering ends, frequently helicoid. *Submerged mycelium:* hyphae as in advancing zone, occasionally up to 6.0μ diameter, with numerous septa.

TYPE OF ROT: white rot of "trees belonging to the order Rosaceae" according to Cartwright and Findlay (55).

DESCRIPTIONS OF CULTURAL CHARACTERS: Baxter (8), Campbell (42), Cartwright and Findlay (55, 56), Davidson, Campbell, and Blaisdell (64), Fisher (72).

Fomes fulvus has a key pattern identical with those of several other species, of which *F. igniarius* is most difficult to separate from *F. fulvus*. The inserted descriptive key points out a number of differences, of which the occurrence of *F. fulvus* on members of the Rosaceae only may be most helpful.

Fomes igniarius (L. ex Fries) Gill.

KEY PATTERN: 1 2 1 2 (5,9) 2 2 2 (2,3) 2 1

CULTURES EXAMINED:

CANADA.—Nova Scotia: Kentville, on *Fagus grandifolia*, F5028. Quebec: Ste. Anne de la Pocatière, on *Pyrus* sp., F6915. Ontario: Petawawa, on *Acer saccharum*, F7972, on *Betula lutea*, F7978, on *B. papyrifera*, F7980, on *Fagus grandifolia*, F7977, on *Ostrya virginiana*, F7974, on *Quercus rubra*, F7975; Radiant, on *Betula papyrifera*, F7403. British Columbia: Cowichan, on *Salix* sp., 8207; Duncan, on *Salix* sp., F1255; Saanichton, on *Cornus nuttallii*, 8204. ENGLAND.—F3310.

CULTURAL CHARACTERS: (Pl. III, Fig. 4; Pl. IV, Figs. 16 to 19).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to five weeks. Advancing zone even, white, with raised aerial mycelium extending to limit of growth. Mat white with tinges of "cream-buff" (3.0Y8.3/4.5), "chamois" (2.0Y7.5/5.8), "Naples yellow" (3.0Y7.8/5.0), and "mustard yellow" (2.0Y7.8/7.5) (one week), remaining pale or assuming deeper colors of "honey yellow" (2.0Y6.7/6.2), "olive-ocher" (3.0Y6.8/6.5), and "tawny-olive" (8.0YR4.8/5.8) (two weeks), to "buckthorn brown" (8.0YR4.8/6.5) (three weeks), (*a*) downy at margin, to cottony and woolly in older parts, with whole surface finally covered with uniform woolly to felty mycelium, or (*b*) with some zones with scanty cottony mycelium, white to "honey yellow" (2.0Y6.7/6.2) and "yellow ocher" (10 0YR 6.8/9.0) over dark brown crustose areas in agar, remainder of the mat cottony to felty, mycelium frequently heaped up at the edge of the crustose areas. Reverse unchanged to the end of two to four weeks, then patchy, with scattered lines and dots of "ochraceous-tawny" (6.0YR4.9/6.3), "cinnamon-brown" (5.0YR3.0/3.0), "mummy brown" (7.5YR2.5/2.3), etc., finally all brown, usually with darker lines and dots, producing a marblelike effect. Odor of wintergreen slight in some isolates, lacking in others. On gallic and tannic acid agars diffusion zones weak to strong, no growth or only a trace on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with inconspicuous simple septa, frequently branched, 1.5–6.0μ diameter. *Aerial mycelium* (peels readily from agar and turns brown in potassium hydroxide): (*a*) hyphae as in advancing zone; (*b*) fiber hyphae, with walls more or less thickened, greenish-yellow to brown, rarely branched, aseptate, 1.0–3.0μ diameter; (*c*) broad hyphae observed in some isolates, with walls slightly thickened, brown, branched, frequently septate, up to 9.0μ diameter; (*d*) cuticular cells arising as irregular swellings on hyphae, at first hyaline with contents staining in phloxine, then dark brown and apparently empty, closely packed together to form a pseudoparenchymatous layer, observed in most isolates. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) some broad hyphae as in (*c*) above.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42), Cartwright and Findlay (55, 56), Davidson, Campbell, and Blaisdell (64), Fritz (74), Hopp (87), Humphrey and Siggers (92), Noecker (118), Verrall (149).

Verrall (149) studied a large number of cultures of *Fomes igniarius* from various hosts and found that they fell into three groups, one consisting of isolates from *Populus* spp., one from *Betula* spp., and one from miscellaneous hosts. The form on *Populus* spp. was segregated by Campbell (42) under the name *Fomes igniarius* var. *populinus* and this practice has been followed in the present study. The isolates from hosts other than *Populus* spp. showed considerable variation, but no more than that exhibited by individual isolates at different times. Hence no correlation of growth type with host seemed possible, and all the cultures were included under *Fomes igniarius*. In preparing a description of the species, an attempt has been made to include this range in growth characters. Separation from other species having the same key pattern must be on the basis of color and topography, as noted in the descriptive key.

Fomes igniarius var. **laevigatus** (Fries) Overh.

KEY PATTERN: 1 2 1 2 (5,9) 2 2 2 (1,2) 2 1

CULTURES EXAMINED:

CANADA.—Ontario: Timagami, on *Betula papyrifera*, F789, on *Betula* sp., F902. British Columbia: Lumby, on *Betula* sp., 9008. UNITED STATES.—Pennsylvania: Detweiler Run, F1956.

CULTURAL CHARACTERS: (Pl. III, Fig. 5; Pl. IV, Figs. 20 to 22).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone even, appressed, hyaline to white, with hyphae well separated. Mat with white border, changing through "cream-buff" (3.0Y8.3/4.5), "chamois" (2.0Y 7.5/5.8), "honey yellow" (2.0Y6.7/6.2), and "clay color" (10.0YR5.8/6.0) to "tawny-olive" (8.0YR4.8/5.8) (one to three weeks), to "sayal brown" (7.0YR5.0/5.5) (four weeks), with little subsequent change in color, slightly raised, cottony in newest growth, then woolly to tufted felty, sometimes interrupted by zones in which aerial mycelium consists of thin white bloom over dark crustose areas, these later being overgrown with felty mycelium. Reverse unchanged at first, then "ochraceous-tawny" (6.0YR4.9/6.3), "cinnamon-brown" (5.0YR 3.0/3.0), and "mummy brown" (7.5YR2.5/2.3) in patches, finally (three to six weeks) all "liver brown" (1.0YR2.3/4.0) and "carob brown" (2.0YR3.1/2.3). Mat peels from agar readily. Odor of wintergreen strong. On gallic and tannic acid agars diffusion zones moderately strong, diameter on gallic acid agar 1.0–2.5 cm., on tannic acid agar no growth to 2.0 cm. diameter.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, frequently branched, 2.0–6.0μ diameter. *Aerial mycelium:* (dark brown in potassium hydroxide) (*a*) hyphae as in advancing zone plentiful; (*b*) fiber hyphae with thick walls, usually dark brown, rarely branched, occasionally septate, 1.5–3.0μ diameter; (*c*) cuticular cells arising as irregular swellings on hyphae, hyaline with contents staining in phloxine, then dark brown, apparently empty, occurring in loosely arranged groups on aerial mycelium or, more frequently, closely packed together to form a pseudoparenchymatous layer. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved trees; canker of *Betula lutea* (Campbell and Davidson (46)).

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42), Davidson, Campbell, and Blaisdell (64).

The rapid to moderately rapid growth, and consistently strong odor of wintergreen should be sufficient to separate cultures of this species from others with which they might be confused.

Fomes igniarius var. **populinus** (Neuman) Campbell

KEY PATTERN: 1 2 1 2 (5,9) 2 2 2 4 2 1

CULTURES EXAMINED:

CANADA.—Ontario: Petawawa, on *Populus grandidentata*, F7976, on *P. tremuloides*, F7973.

CULTURAL CHARACTERS: (Pl. III, Fig. 6; Pl. IV, Figs. 23 to 25).

GROWTH CHARACTERS.—Growth very slow, radius 4.2–8.5 cm. in six weeks. Advancing zone even at first, becoming bayed after two to four weeks, white, raised aerial mycelium extending to limit of growth. Mat with white border, then "colonial buff" (6.0Y8.5/5.5), "chamois" (2.0Y7.5/5.8), "old gold" (3.0Y5.8/5.5) (one week), becoming "honey yellow" (2.0Y6.7/6.2), "Isabella color" (1.0Y5.5/4.3), "snuff brown" (7.0YR3.9/3.5), and "Saccardo's umber" (9.0YR3.8/3.5) (two to five weeks), to "buckthorn brown" (8.0YR 4.8/6.5) and "cinnamon-brown" (5.0YR3.0/3.0) (six weeks), raised, thick woolly to plush-like, frequently grown to top of Petri dish near inoculum, and sloping gradually to edge, with characteristic grooves radiating from inoculum to marginal bays, some isolates occasionally producing crustose areas, dark brown with thin white bloom over surface. Reverse unchanged in color, with conspicuous zones and radiating lines, except below crustose areas, where agar is "Mars brown" (4.5YR2.8/3.0). Mat peels from agar readily, leaving white bloom. Odor of wintergreen strong. On gallic and tannic acid agars diffusion zones weak to moderately strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with inconspicuous simple septa, frequently branched, 1.5–4.5μ diameter. *Aerial mycelium:* (turns brown in potassium hydroxide) (*a*) hyphae as in advancing zone; (*b*) fiber hyphae buffy brown to dark brown, walls thick and lumina narrow except at tips, rarely branched, aseptate, 1.5–4.5μ diameter, curving, interwoven to form mat; (*c*) cuticular cells arising as swellings on hyphae or as inflated hyphal tips, at first hyaline with contents stained in phloxine, then dark brown, apparently empty, firmly packed together to form pseudoparenchymatous layer. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of *Populus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42), Davidson, Campbell, and Blaisdell (64), Fritz (74), Hopp (87), Verrall (149).

The slow-growing thick woolly mat over agar that remains unchanged in color or becomes dark only below isolated crustose areas, the strong odor of wintergreen, and the occurrence only on *Populus* spp. make *Fomes igniarius* var. *populinus* distinct from all other species treated in this study.

Fomes nigrolimitatus (Romell) Egel.

KEY PATTERN: 2 2 1 2 (3,9) 2 2 2 4 2 1

CULTURES EXAMINED:

CANADA.—British Columbia: Vancouver, on *Picea* sp., 9159, 10085. ALASKA.—On *P. sitchensis*, 11686.

CULTURAL CHARACTERS: (Pl. III, Fig. 7; Pl. IV, Figs. 26 to 29).

GROWTH CHARACTERS.—Growth very slow, radius 4.0–6.0 cm. in six weeks. Advancing zone even for two to three weeks, then deeply bayed, with slightly raised aerial mycelium extending to limit of growth, forming white border, broad at first, becoming narrower after three to four weeks. Mat "chamois" (2.0Y7.5/5.8), "yellow ocher" (10.0YR6.8/9.0), and "raw sienna" (8.0YR5.3/8.5) (two weeks) to "ochraceous-tawny" (6.0YR4.9/6.3),

"buckthorn brown" (8.0YR4.8/6.5), and "cinnamon-brown" (5.0YR3.0/3.0) near inoculum (four weeks), slightly raised, loosely arranged, cottony-woolly, thin enough to allow darker color of agar to show through, becoming duller in color—"deep brownish drab" (2.0YR3.7/1.5), "buckthorn brown" (8.0YR4.8/6.5), "cinnamon-brown" (5.0YR3.0/3.0), and "Prout's brown" (5.5YR2.8/3.2) (six weeks), collapsed, thin felty. Reverse colored after one week, sometimes green in narrow zone, then "ochraceous-tawny" (6.0YR4.9/6.3), "hazel" (3.0YR3.8/5.0), and "bister" (4.5YR3.0/3.0), the diffusion zone occasionally extending beyond mat, in which case growth is retarded. Odor none or indistinct. On gallic and tannic acid agars diffusion zones strong, trace of growth on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, branched, with simple septa, 1.5–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) hyphae with thin walls, pale brown, frequently septate and branched, often collapsed and distorted, 6.0–12.0μ diameter; (*c*) hyphae with dark brown walls, frequently septate and branched, the branches often lying parallel to parent hyphae to form small strands, 1.5–3.0μ diameter; (*d*) bulbils numerous, formed on narrow brown hyphae, apparently by one or more narrow branches coiling tightly about parent hypha. *Submerged mycelium:* (*a*) hyphae and (*b*) bulbils as described above; (*c*) crystals octahedral, numerous.

TYPE OF ROT: white pocket rot of coniferous trees in Western Canada and United States.

DESCRIPTIONS OF CULTURAL CHARACTERS: Humphrey and Siggers (92).

If, in cultures of *Fomes nigrolimitatus*, bulbils are seen, recognized as such, and included in the key pattern, then the key pattern for this species is unlike that for any other species, and the culture is readily identified. To meet the possibility of bulbils being overlooked in examining cultures, the species is included with those having no "special structures", and falls with *Polyporus dryadeus* and *Poria tsugina*. The restriction of *Fomes nigrolimitatus* to western conifers, the occurrence of bulbils in culture, and the color and topography of its mat, should be sufficient to separate it from these species.

Fomes officinalis (Vill. ex Fries) Faull

KEY PATTERN: 2 1 2 1 9 1 (1,2) 2 4 2 2

CULTURES EXAMINED:

CANADA.—British Columbia: Cowichan, on *Pseudotsuga taxifolia*, 8214; Merritt, on *Pinus ponderosa*, F1309; Queen Charlotte Islands, on *Picea sitchensis*, 10734; Vancouver, on log, 9503. UNITED STATES.—Oregon: Oregon Caves, on *Abies* sp., F1276. Washington: on *Larix occidentalis*, F7196.

CULTURAL CHARACTERS: (Pl. III, Fig. 8; Pl. IV, Figs. 30 to 33).

GROWTH CHARACTERS.—Growth very slow, radius 4.0–7.0 cm. in six weeks. Advancing zone regular to bayed, in some isolates with raised aerial mycelium to limit of growth, in others with appressed hyaline growth preceding the raised mat. Mat white, compact for two to three weeks, cottony to velvety, uniform, then more loosely arranged, cottony to woolly, more or less patchy, with some areas in which aerial mycelium is scanty and appressed, other areas in which it is raised, frequently appearing farinaceous over cottony mycelium. Reverse unchanged for two to three weeks, then slightly yellowish to "honey yellow" (2.0Y6.7/6.2). Odor fragrant, fruity. On gallic and tannic acid agars no diffusion zones, trace of growth to 2.0 cm. diameter on gallic acid agar, no growth or only a trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, thin-walled, with conspicuous clamp connections, frequently branched, 3.0–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) conidia numerous, borne singly at the tips of branches that are usually narrower than the main hyphae, subglobose to ovoid, thin-walled, 4.5–7.5 $\times$ 3.0–4.5μ; (*c*) chlamydospores numerous, terminal and intercalary, with fairly thick walls and contents staining deeply in phloxine, 10.5–15.0 $\times$ 6.0–9.0μ. *Submerged mycelium:* (*a*) hyphae and (*b*) chlamydospores as described above; (*c*) crystals numerous, octahedral.

TYPE OF ROT: brown cubical rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Campbell (42), Cartwright and Findlay (54, 56), Davidson, Campbell, and Blaisdell (64), Faull (70), Humphrey and Siggers (92).

Authors who have described the cultural characters of this species have considered all the spores to be chlamydospores. It would appear, however, that the spores described above as conidia differ from the chlamydospores in their occurrence on aerial mycelium exclusively, their formation at the tips of specialized branches, their smaller size, and their thin walls. When the spores are considered as conidia and chlamydospores, the resulting key pattern does not coincide with those for any other species; if they are interpreted as being all chlamydospores, then the key pattern coincides with that for *Poria asiatica*, the chlamydospores of which are usually rough-walled, and all of large size. Cultures of *Fomes officinalis* resemble closely the cultures of *Poria carbonica*, but the characteristic special hyphae of the latter species, as well as its more rapid rate of growth, make separation of the two species possible.

Fomes ohiensis (Berk.) Murr.

KEY PATTERN: 1 1 1 1 9 2 2 2 4 2 2

CULTURES EXAMINED:

UNITED STATES.—Locality and host unknown, F8005.

CULTURAL CHARACTERS: (Pl. III, Fig. 9; Pl. IV, Fig. 34).

GROWTH CHARACTERS.—Growth very slow, radius 4.6–5.8 cm. in six weeks. Advancing zone even, hyaline, appressed. Mat white, very thin, appressed, zonate, farinaceous with "dots" of more compact mycelium, forming a tough film on surface of agar. Reverse unchanged. Odor yeasty. On gallic and tannic acid agars diffusion zones moderately strong to strong, no growth on gallic acid agar, trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 2.2–3.0(–4.5)μ diameter. Hyphae at surface and within agar all like those of advancing zone.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42), Davidson, Campbell, and Blaisdell (64).

This description of *Fomes ohiensis* is based on the only culture of the species available, but it agrees closely with the description given by Campbell (42), and so has been included. In the key, *F. ohiensis* coincides with only one other species, *Stereum Murraii*, their slow rate of growth separating them from all other species with similar characters. Macroscopically, cultures of *Fomes ohiensis* and *Stereum Murraii* are very different, the former being appressed, farinaceous, with dots of more compact mycelium, the latter being slightly raised, furry or velvety, all compactly arranged and opaque.

Fomes Pini (Thore) Lloyd

KEY PATTERN: (1,2) 2 1 2 (2,7) 2 2 2 4 2 1

CULTURES EXAMINED:

CANADA.—Quebec: Champlain County, on *Picea glauca*, 10267, 10268, on *P. mariana*, 10265, on *Pinus Banksiana*, 10266, 10269, 10306; Gaspé County, on *Picea mariana*, F2366, on *P. rubra*, F955; Montreal, on conifer, 10204. British Columbia: Queen Charlotte Islands, on *P. sitchensis*, 10729, 11725, 11726, 11727, 11728. UNITED STATES.—Virginia: F2162. Host and locality not known, F372, F2163.

CULTURAL CHARACTERS: (Pl. III, Fig. 10; Pl. IV, Figs. 35 to 38).

GROWTH CHARACTERS.—Growth very slow, radius 5.0–8.0 cm. in six weeks. Advancing zone even, white, raised aerial mycelium extending to limit of growth. Mat white to "colonial buff" (6.0Y8.5/5.5), "cream-buff" (3.0Y8.3/4.5), and "chamois" (2.0Y7.5/5.8) (one week), to "primuline yellow" (1.5Y7.5/9.5) and "honey yellow" (2.0Y6.7/6.2) (two weeks), with flecks or patches of "tawny-olive" (8.0YR4.8/5.8), "antique brown" (8.0YR4.2/5.5), or "cinnamon-brown" (5.0YR3.0/3.0) in some isolates (three to six weeks), raised, cottony-woolly to woolly, tufted to form a rough surface, occasionally with sectors or small areas in which aerial mycelium is lacking and colored agar is exposed. Reverse more or less completely colored, "ochraceous-tawny" (6.0YR4.9/6.3), "Sudan brown" (5.5YR3.8/5.5), "Brussels brown" (5.0YR3.5/4.0), and "Prout's brown" (5.5YR2.8/3.2). Odor none. On gallic and tannic acid agars diffusion zones weak to moderately strong, trace of growth to 1.5 cm. diameter on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 2.0–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) hyphae with slightly thicker walls, hyaline to greenish-yellow, with contents hyaline, yellow, or brown, septate, branched, 2.2–6.0μ diameter, characteristically with scattered dark brown cells in hyaline or pale hyphae, frequently helicoid; (*c*) expansions on hyphae up to 7.5μ diameter, occurring singly or in series, in a terminal or intercalary position, usually with walls brown and thickened so that lumina are visible only in expansions; (*d*) setae numerous in some isolates, rare or apparently lacking in others, slender, pointed, with walls thick and dark brown, 30.0–67.0 $\times$ 4.5–7.5μ. *Submerged mycelium:* hyphae as in advancing zone, up to 7.5μ diameter.

TYPE OF ROT: red ring rot of coniferous and, rarely, broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Abbott (1), Badcock (3), Campbell (42), Cartwright and Findlay (51, 54, 56), Davidson, Campbell, and Blaisdell (64), Fritz (74), Humphrey and Siggers (92), Owens (125), Percival (126).

Fomes Pini occurs frequently among the cultures of wood-decaying fungi received for identification. Recognition of the species is difficult because of the variability of the cultures, which has already been recorded by Owens (125) and others. The occurrence of setae is a useful diagnostic character when present, but they have not been found in all isolates growing in Petri dishes, and they were found only rarely in cultures growing in tubes. Their occurrence in cultures of this species has not been mentioned by other authors. The brown thick-walled hyphae with swellings occurring in series or singly have been observed in all isolates of *F. Pini*, although their appearance in some isolates is delayed until the cultures are six weeks old. These structures constitute a reliable criterion for the separation of *F. Pini* cultures from those of other species.

Fomes pinicola (Sw.) Cooke

KEY PATTERN: (1,2) 1 2 1 9 (1,2) 2 2 (2,3) 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Portage River, on *Picea mariana*, 11594; Gaspé County, F957. Ontario: Minaki, F1268. Manitoba: Victoria Beach, on *Populus balsamifera*, F3249. Saskatchewan: Lake Waskesiu, on conifer, F2380. Alberta: Calgary, on *Populus balsamifera*, F3510. British Columbia: Kaslo, on *Prunus* sp., 8206; Lumby, on *Picea Engelmanni*, 9033; Mt. Arrowsmith, on *Tsuga heterophylla*, 8568; Queen Charlotte Islands, on *Picea sitchensis*, 11142, 11146, 11150, 11151. *United States.*—Alaska: Hot Springs, on *P. glauca*, F6925. California: Plumas National Forest, on *Abies concolor*, F6624. Maine: Van Buren, on *A. balsamea*, 8234. POLAND.—Pulawy, on *Prunus avium*, F7121; Rabka, on *Picea excelsa*, F7120. JAPAN.—Hokkaido, on *P. yezoensis*, F6895.

CULTURAL CHARACTERS: (Pl. III, Fig. 11; Pl. IV, Figs. 39 to 43).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in three to six weeks. Advancing zone even, hyaline and appressed in narrow zone, the hyphae appearing coarse and curving by transmitted light. Mat white, at first slightly raised, cottony or cottony-woolly, most isolates remaining unchanged and uniform in appearance, others forming scattered dots of more compact mycelium, especially noticeable by transmitted light, the remainder of the cultures becoming appressed, subfelty or farinaceous around inoculum. Reverse unchanged. Odor none or faintly of apples. On gallic and tannic acid agars no diffusion zones, colonies 1.5–4.0 cm. diameter on gallic acid agar, trace to 3.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae nodose-septate, frequently branched at and between septa, 1.5–4.5(–6.0)μ diameter; (*b*) chlamydospores numerous in some isolates, rare or lacking in the remainder, usually limited to the advancing zone, especially in mycelium that is grown against wall of Petri dish remote from inoculum, terminal and intercalary, with walls thin or slightly thickened, 6.0–18.0 × 6.0–9.0μ, apparently disappearing (probably through germination) from older parts of mat in most isolates. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently with contents that appear oily; (*b*) fiber hyphae numerous, with walls thick and refractive, lumina narrow or apparently lacking, aseptate, only rarely branched, 1.0–4.5μ diameter, closely interwoven; (*c*) chlamydospores as described above in a few isolates. *Submerged mycelium:* (*a*) hyphae as in advancing zone, but more frequently branched, up to 9.0μ diameter; (*b*) crystals numerous, octahedral.

TYPE OF ROT: brown cubical rot of coniferous and broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Campbell (42), Cartwright and Findlay (54, 56), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Fritz (74), Humphrey and Siggers (92), Mounce (109), Mounce and Macrae (115).

The variability of cultures of *Fomes pinicola* results in the species appearing in eight places in the key, and necessitates its separation from a number of other species with identical key patterns. Descriptive keys have been inserted to facilitate this separation but the lack of distinctive characters by cultures of *F. pinicola* makes this difficult. However, once one has become familiar with the appearance of cultures of *F. pinicola*, they are readily recognized, more by this lack of distinctive markings than by any characteristic that can be included in a key or description.

Fomes pomaceus (Pers.) Lloyd

See *Fomes fulvus*.

Fomes rimosus Berk.

KEY PATTERN: 1 2 1 2 9 2 2 2 (2,3) 2 1

CULTURES EXAMINED:

UNITED STATES.—Maryland: Bethesda, on *Robinia pseudoacacia*, F1690. New York: Spafford, on *R. pseudoacacia*, F1305. North Carolina: Asheville, on *R. pseudoacacia*, F2164. Locality and host not known, F2165.

CULTURAL CHARACTERS: (Pl. III, Fig. 12; Pl. IV, Figs. 44 and 45).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to six weeks. Advancing zone even, hyaline to white, submerged or sparsely downy. Mat with white border, changing abruptly to "clay color" (10.0YR5.8/6.0), "yellow ocher" (10.0YR 6.8/9.0), or "buckthorn brown" (8.0YR4.8/6.5) (one week), later with greater range of colors, from white through "colonial buff" (6.0Y8.5/5.5), "cream-buff" (3.0Y8.3/4.5), "chamois" (2.0Y7.5/5.8), "tawny-olive" (8.0YR4.8/5.8), to "old gold" (3.0Y5.8/5.5) and "mustard yellow" (2.0Y7.8/7.5) (four to six weeks), the brighter colors frequently assumed by the older cultures being noteworthy, at first appressed, downy to cottony, becoming cottony-floccose, finally felty and tufted. Reverse unchanged below newest growth, then "ochraceous-tawny" (6.0YR4.9/6.3), "cinnamon-brown" (5.0YR3.0/3.0), and "Prout's brown" (5.5YR2.8/3.2). Odor none. On gallic and tannic acid agars diffusion zones weak to moderately strong, trace of growth on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, branched, 3.0–7.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, becoming yellow and brown; (*b*) fiber hyphae with walls slightly thickened, occasionally pale yellow, more frequently dark brown, branched, occasionally septate, 2.0–3.0μ diameter. *Submerged mycelium:* (*a*) hyphae as in advancing zone, frequently branched; (*b*) crystals numerous, octahedral.

TYPE OF ROT: spongy yellow heart rot of living *Robinia pseudoacacia*.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42), Davidson, Campbell, and Blaisdell (64), Humphrey and Siggers (92), Long and Harsch (98).

Fomes rimosus is usually considered to be specific to *Robinia pseudoacacia*, and this host relationship, along with the occurrence of unusually broad hyphae in the cultures, should aid in the separation of this species from the numerous other species that have identical key patterns.

Fomes roseus (Alb. and Schw. ex Fries) Cooke

KEY PATTERN: (1,2) 1 (1,2) 1 9 2 2 2 2 1 (1,2)

CULTURES EXAMINED:

CANADA.—Quebec: Gaspé County, on *Picea glauca*, F2355. Ontario: Timagami, on *P. glauca*, F1449. British Columbia: Vancouver, on *Pseudotsuga taxifolia*, F2374. UNITED STATES.—Host and locality not known, F2929.

CULTURAL CHARACTERS: (Pl. III, Fig. 13; Pl. IV, Figs. 46 to 49).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three weeks. Advancing zone even, hyaline and appressed so that it is difficult to see limit of growth. Mat white to "tilleul buff" (9.0YR8.7/1.5), "shell pink" (2.0YR8.4/3.7), "light pinkish cinnamon" (7.0YR7.5/4.5), "vinaceous-buff" (7.0YR7.0/3.5), and "vinaceous-fawn" (4.5YR6.7/3.5) around inoculum after three to four weeks, downy or farinaceous in some isolates, becoming more compact felty after three to four weeks and forming a granular to irregularly pored fruiting surface. Reverse unchanged or with scattered areas "hazel" (3.0YR3.8/5.0) to "Prout's brown" (5.5YR2.8/3.2) after five to six weeks. Odor slightly fruity. On gallic and tannic acid agars diffusion zones lacking or very weak, diameter 2.0–2.5 cm. on gallic acid agar, trace to 1.5 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 1.5–4.5(–6.0)μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae rare to numerous, with walls thick and refractive, lumina narrow or apparently lacking, sparingly branched, apparently aseptate, 2.0–3.0μ diameter. *Fruit body:* (*a*) nodose-septate and (*b*) fiber hyphae as above; (*c*) basidia 4.5μ diameter, bearing four spores; (*d*) basidiospores hyaline, even, elongate-ellipsoid, slightly curved, 4.5–6.0 × 1.5–2.7μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, in irregular clumps.

TYPE OF ROT: brown cubical rot of coniferous and, rarely, broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42), Cartwright and Findlay (54), Davidson, Campbell, and Blaisdell (64), Davidson, Lombard, and Hirt (68), Fritz (74), Mounce and Macrae (114), Snell (138), Snell, Hutchinson, and Newton (140).

In the key no code number is allotted to a color change from white to pink and vinaceous, and cultures exhibiting these colors fall with cultures that remain white. Thus the key patterns for *Fomes roseus* may coincide with those for *Pleurotus ostreatus*, *Polyporus hirsutus*, *Schizophyllum commune*, and others, from all of which separation can usually be made on the basis of color. Cultures of *Fomes roseus* and *F. subroseus* are similar and have been separated by Snell, Hutchinson, and Newton (140), and Campbell (42) on the basis of their different rates of growth at certain temperatures. In the present study, in the four cultures of *F. roseus* examined, no chlamydospores were observed, while they occurred in all eight cultures of *F. subroseus* studied. Two cultures filed in the stock culture collection under *F. roseus* were found to have chlamydospores. On carrying out interfertility tests between these cultures and authentic cultures of *F. roseus* and *F. subroseus* it was found that they were interfertile with *F. subroseus* and therefore belonged to that species and not to *F. roseus*. This provided additional evidence, but more is required to establish definitely that chlamydospores are regularly present in *F. subroseus*, absent in *F. roseus*.

Fomes scutellatus (Schw.) Cooke

KEY PATTERN: 1 2 1 1 9 2 2 2 (2,3) (1,2) 2

CULTURES EXAMINED:

CANADA.—Ontario: Chalk River, on *Alnus incana*, F3255; Ottawa, on *A. incana*, F3444.

CULTURAL CHARACTERS: (Pl. III, Fig. 14; Pl. IV, Figs. 50 to 52).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in three to six weeks. Advancing zone even, hyaline, appressed or with slightly raised aerial mycelium to limit of growth. Mat white at first, becoming "cream-buff" (3.0Y8.3/4.5) to "cinnamon-brown" (5.0YR3.0/3.0) in isolated areas after three to four weeks, the first growth over the inoculum cottony to woolly, appressed over agar, becoming slightly raised, floccose to cottony-woolly, lacunose, forming a tough, coherent mat even where thin, after three to four weeks with scattered loose-cottony to compact-felty balls of mycelium, some of which develop granular fruiting surfaces after five to six weeks. Reverse unchanged. Odor of almonds. On gallic and tannic acid agars diffusion zones weak to moderately strong, no growth on gallic acid agar, no growth or only a trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline with conspicuous clamp connections, frequently branched at and between septa, 1.5–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, becoming greenish-yellow in colored areas; (*b*) fiber hyphae

abundant, thick-walled with narrow lumina, apparently aseptate, frequently branched, the branch forming a right angle with the parent hypha, curving and firmly interwoven, 1.5–3.0μ diameter; (*c*) basidiospores (from spore deposit) cylindric, 7.5–8.0 × 2.2–3.0μ. *Submerged mycelium:* hyphae hyaline, thin-walled, nodose-septate, with many short irregular branches and projections, 2.2–4.5μ diameter; (*c*) crystals numerous, needlelike.

TYPE OF ROT: white rot of broad-leaved trees, usually *Alnus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Campbell (42), Davidson, Campbell, and Blaisdell (64).

Faster-growing cultures that fruit and all slow-growing cultures of *Fomes scutellatus* have key patterns that fall alone in the key, but cultures that cover the plates in three to four weeks and fail to fruit have a key pattern that coincides with those for *Collybia radicata* and *Daedalea confragosa*. Under each of these species mention is made of distinguishing characters, of which the preference of *Fomes scutellatus* for *Alnus* spp. is most helpful.

Fomes subroseus (Weir) Overh.

KEY PATTERN: (1,2) 1 (1,2) 1 9 1 2 2 2 1 2

CULTURES EXAMINED:

CANADA.—Quebec: Champlain County, on *Picea mariana*, 10278. Ontario: Keewatin, on conifer, F2392. British Columbia: Saanichton, on *Pseudotsuga taxifolia*, 8203, on conifer, 8184. UNITED STATES.—New York: Oswego County, on conifer, F1300. Oregon: Benton County, on *Pseudotsuga taxifolia*, F1639. Host and locality not known, F1000.

CULTURAL CHARACTERS: (Pl. III, Fig. 15; Pl. IV, Figs. 53 to 58).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, hyaline and appressed in zone 0.5–1.0 cm. broad. Mat white to "shell pink" (2.0YR8.4/3.7) (one week), "pale vinaceous-pink" (1.0YR7.8/3.3), and "vinaceous-pink" (2.0YR7.1/4.5) (two weeks), to "vinaceous-fawn" (4.5YR6.7/3.5) (four weeks), at first downy, becoming slightly raised, cottony (two weeks), to floccose-cottony and pitted (four weeks), with pored areas over inoculum after one to two weeks and covering most of surface after six weeks, waxy, the dissepiments thick and pores relatively small. Reverse unchanged. Odor sweet. On gallic and tannic acid agars diffusion zones lacking or very weak, diameter 1.5–3.0 cm. on gallic acid agar, trace to 1.5 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, occasionally up to 6.0μ diameter, with walls irregularly thickened; (*b*) fiber hyphae numerous, with walls thick and lumina narrow or apparently lacking, occasionally branched, aseptate, 1.5–4.0μ diameter; (*c*) chlamydospores rare, intercalary or terminal, walls thin, ovoid to elongate, 10.5–24.0 × 6.0–7.5μ. *Fruit body:* (*a*) basidia 4.5–6.0μ diameter, bearing four spores; (*b*) basidospores hyaline, even, allantoid, 6.0–8.0 × 1.5–2.0μ. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as described above; (*c*) crystals numerous, irregular, frequently in large aggregates.

TYPE OF ROT: brown cubical rot of coniferous and, rarely, broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42), Cartwright and Findlay (54, 56), Davidson, Campbell, and Blaisdell (64), Humphrey and Siggers (92), Mounce and Macrae (114), Snell, Hutchinson, and Newton (140).

Fomes subroseus, having two variable characters, falls with four groups of species in the numerical key. The distinctive "shell pink" to "vinaceous-pink" color of the mat is characteristic, and not to be confused with the color

of any other species having the same key pattern. Its similarity to *F. roseus* is discussed under that species, with evidence that chlamydospores occur only in *F. subroseus* and so provide a means of separating the two species.

Ganoderma applanatum (Pers.) Pat.

KEY PATTERN: (1,2) (1,2) 1 1 5 2 2 2 (2,4) 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Eardley, on *Abies balsamea*, F7524; Ste. Anne de la Pocatière, on *Pyrus* sp., F6914. Ontario: Ottawa, on *Quercus* sp., 9295. British Columbia: Saanichton, on *Pseudotsuga taxifolia*, 8180. UNITED STATES.—Locality and host not known, F2019, F2026, F2159. JAPAN.—Kyoto, F1342.

CULTURAL CHARACTERS: (Pl. V, Fig. 1; Pl. VI, Figs. 1 to 4).

GROWTH CHARACTERS.—Growth moderately rapid in some isolates, plates covered in three weeks, to very slow in others, plates covered in six or more weeks. Advancing zone even, appressed or with slightly raised downy mycelium to limit of growth. Mat white at first and remaining so or becoming "tilleul buff" (9.0YR8.7/1.5) to "avellaneous" (8.0YR 6.2/3.5), "cream buff" (3.0Y8.3/4.5) to "Isabella color" (1.0Y5.5/4.3), or "olive-buff" (4.0Y7.5/3.0) to "dark olive-buff" (4.0Y6.5/4.5) after two to four weeks, the newest growth appressed, translucent, cottony or farinaceous, later opaque, compact, felty or pellicular in scattered areas or over whole surface, the color occurring in these compact areas, frequently wrinkled. Reverse unchanged or "olive-ocher" (3.0Y6.8/6.5) to "honey yellow" (2.0Y 6.7/6.2) under colored areas. Odor none. On gallic and tannic acid agars diffusion zones weak to strong, no growth to 1.0 cm. diameter on gallic acid agar, trace to 1.5 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, branched, the branches usually occurring at the septa, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae very numerous, with walls thick and refractive, lumina narrow or apparently lacking, aseptate, frequently branched, 1.0–2.0(–4.5)μ diameter, closely interwoven; (*c*) cuticular cells (formed at surface of agar) appearing first as swellings on nodose-septate hyphae, with contents staining in phloxine, later empty, with walls slightly thickened, compactly arranged to form pseudoparenchymatous layer; (*d*) staghorn hyphae present in some isolates. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white mottled rot of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Campbell (42), Cartwright and Findlay (51, 52, 53, 55, 56), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Fritz (74), Hopp (88), Humphrey and Siggers (92), White (151).

Coleman (59), having made a careful study of the spore wall in several species of *Ganoderma*, wrote "It would seem to be a character of much greater importance from a systematic standpoint than many of those at present being used in the classification of the Polyporaceae", and "I consider that all forms showing the spore characteristics described should be brought together under the genus *Ganoderma* Karst". Those taxonomists who concur in this opinion follow Patouillard in including *Ganoderma applanatum* in this genus, while others who consider the structure of the upper surface of the fruit body as a more important diagnostic character in delimiting the genus, put the species under *Fomes applanatus*. In the present study, its cultural characters were found to be so similar to those of the species of *Ganoderma* examined as to indicate relationship, and to warrant its inclusion in that genus. In fact, its

separation from other species of *Ganoderma* with which it coincides in the key is exceedingly difficult, and information such as that *G. oregonense* is limited to western conifers and that *G. lobatum* is rare and will probably not be encountered in Canada, must be considered in addition to cultural characters in making identifications.

Ganoderma lobatum (Schw.) Lowe

KEY PATTERN: 1 2 1 1 5 2 2 2 2 2 2

CULTURES EXAMINED:

UNITED STATES.—Indiana: on old stump, F8008. Louisiana: on *Acer* sp., F8007. Maryland: on *Quercus* sp., F8006.

CULTURAL CHARACTERS: (Pl. V, Fig. 2; Pl. VI, Figs. 5 to 8).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone hyaline to white, even, fimbriate. Mat distinctly two-zoned: outer zone 1–2 cm. broad, white, slightly raised, short cottony with radiating growth lines; inner zone "cream-buff" (3.0Y8.3/4.5) (one week) to "chamois" (2.0Y7.5/5.8) and "avellaneous" (8.0YR6.2/3.5), appressed, farinaceous to felty, becoming cartilaginous and furrowed, this type of growth finally extending over whole surface. Reverse unchanged to "chamois" (2.0Y7.5/5.8) and "honey yellow" (2.0Y6.7/6.2) below central part, conspicuously veined. No odor. On gallic and tannic acid agars diffusion zones weak to moderately strong, no growth to 2.0 cm. diameter on gallic acid agar, trace to 3.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, thin-walled, nodose-septate, frequently branched, 2.2–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, hyaline to buffy brown, with walls thick and lumina narrow or apparently lacking, frequently branched, 2.0–3.0μ diameter; (*c*) cuticular cells arising as globose to irregular swellings on nodose-septate hyphae, hyaline to buffy brown, closely packed together and interwoven with fiber hyphae to produce the tough felty pellicle of the inner zone; (*d*) staghorn branched hyphae numerous in some isolates, rare in others, produced as branches from nodose-septate hyphae. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67).

Lowe (99), on the basis of the morphological characters of the fruit body, transferred this species from *Fomes* to *Ganoderma* and this disposition of it is corroborated by cultural studies, which have shown cultures of *G. lobatum* to be similar to those of the other species of *Ganoderma* examined. Cultures of *G. applanatum* and *G. lobatum* are almost indistinguishable. Fruit bodies of *G. lobatum* are found only rarely and no collections have been recorded from Canada except from the southernmost part of Ontario, while *G. applanatum* has a wide host and geographic range. Hence there is much greater likelihood of encountering *G. applanatum* than *G. lobatum* in cultures from rots.

Ganoderma lucidum (Leyss. ex Fries) Karst.

KEY PATTERN: 1 (1,2) 1 1 5 1 2 2 1 2 3

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, on *Gleditsia macrantha*, 10222. UNITED STATES.—On *Quercus* sp., F2040. Host and locality not known, F3055.

CULTURAL CHARACTERS: (Pl. V, Fig. 3; Pl. VI, Figs. 9 to 13).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white and remaining so or becoming "wood brown" (7.0YR5.7/4.0) (two weeks), with color subsequently masked by overgrowth of whitish 'bloom', at first slightly raised, cottony, then appressed, felty to pellicular with farinaceous surface, traversed by deep wrinkles or grooves. Reverse unchanged for two or three weeks, then with scattered patches of "honey yellow" (2.0Y6.7/6.2) to "buckthorn brown" (8.0YR4.8/6.5), finally bleached, with wrinkles prominent, producing a veined appearance. No odor. On gallic acid agar diffusion zone weak to strong, no growth or diameter up to 4.0 cm.; on tannic acid agar diffusion zone moderately strong to strong, diameter 2.0–4.0 cm.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5(–6.0)μ diameter. *Aerial mycelium* (thin tough skin that peels from agar): (*a*) hyphae as in advancing zone, with frequent branches and numerous small projections; (*b*) fiber hyphae very numerous, with walls thick and refractive, lumina narrow or apparently lacking, except in main hyphae, frequently branched, the ends long, slender, curving and interwoven, 1.0–3.0μ diameter; (*c*) cuticular cells thin-walled, produced by inflation of nodose-septate hyphae, at first with contents staining in phloxine, then empty, closely compacted and interwoven with fiber hyphae and staghorn hyphae to form pseudoparenchymatous layer, which may remain hyaline or become brown; (*d*) chlamydospores very numerous, walls slightly thickened, terminal and intercalary, broadly ovoid to elongate, 12.0–21.0 × 7.5–10.5μ; (*e*) staghorn branched hyphae with minute branches in all planes very numerous in 10222, not observed in other isolates. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as described above.

TYPE OF ROT: soft spongy white rot of broad-leaved trees (see below).

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64) (under *Polyporus lucidus*), Davidson, Campbell, and Vaughn (67) (under *P. lucidus*), Humphrey and Siggers (92).

As a result of a comparison of European collections of *Polyporus lucidus*, which occurs commonly on broad-leaved trees and more rarely on coniferous trees in Europe, with American collections of *Ganoderma Tsugae* from coniferous trees, usually *Tsuga* spp., Atkinson (2) concluded that they should be brought together in one species, *Ganoderma pseudoboletum*. Haddow (79) made a critical study of European and American collections of *G. lucidum* and American collections of *G. Tsugae* and concluded that there were no constant morphological differences and that host specificity was not a valid basis for separation of the species. Therefore he agreed with Atkinson in placing the two under one species, for which he used the accepted name, *Ganoderma lucidum*. Boyce (35), Lowe (99), and others have followed this practice, but Overholts (119) has retained *G.* (*Polyporus*) *Tsugae* in specific rank. In the present study the three cultures of *G. lucidum* isolated from fruit bodies on broad-leaved trees were distinguishable from the four cultures of *G. Tsugae* from *Tsuga* spp. on the basis of chalmydospore production, which was prolific in all the cultures of *G. lucidum* and completely lacking in those of *G. Tsugae*. Because of this difference, the species have been treated separately, but this does not constitute an argument for their separation in taxonomic studies, since the number of isolates in each species is too small to provide convincing evidence. Interfertility tests are required to establish conclusively whether one or two species are involved.

Ganoderma lucidum is unique among the *Ganoderma* species studied in having chlamydospores and therefore its key pattern does not coincide with that for any of the other species.

Ganoderma oregonense Murr.

KEY PATTERN: 2 (1,2) 1 1 5 2 2 2 2 2 (1,2)

CULTURES EXAMINED:

CANADA.—British Columbia: Little Qualicum River, on *Abies grandis*, F8240; Vancouver, on *Tsuga heterophylla*, F572; on stump, F1012. UNITED STATES.—Oregon: Oregon Caves, on *Abies concolor*, F1274.

CULTURAL CHARACTERS: (Pl. V, Fig. 4; Pl. VI, Figs. 14 to 16).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three weeks. Advancing zone even, hyaline, appressed, with almost no aerial mycelium over outer zone, 1.0–1.5 cm. broad. Mat white at first, with more or less extensive areas of "cream-buff" (3.0Y 8.3/4.5), "chamois" (2.0Y7.5/5.8), and "old gold" (3.0Y5.8/5.5) after three to four weeks, appressed, felty with farinaceous surface, wrinkled, the furrows cutting into agar and showing as a reticulate network on reverse. Reverse "honey yellow" (2.0Y6.7/6.2) to "cinnamon-brown" (5.0YR3.0/3.0) after three to four weeks. Odor fairly strong, fragrant. On gallic and tannic acid agars diffusion zones moderately strong to strong, no growth or only a trace on gallic acid agar, diameter 1.2–2.0 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–5.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, becoming broken into short lengths or converted into cuticular cells; (*b*) cuticular cells elongate to globose, irregular, at first deeply stained in phloxine, later empty, compactly arranged to form a pseudoparenchymatous layer. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: soft spongy white rot of western coniferous trees, especially "western hemlock and balsam firs" (Boyce).

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Davidson, Campbell, and Blaisdell (64).

The lack of fiber hyphae and the permanent color in the agar of cultures of *Ganoderma oregonense* provide reliable means of distinguishing this from other species of *Ganoderma* in culture. In addition, the fact that it is known only on western conifers removes it from the list of species likely to be encountered in other regions and on other hosts.

Ganoderma Tsugae Murr.

KEY PATTERN: 2 (1,2) 1 1 5 2 2 2 2 2 (2,3)

CULTURES EXAMINED:

CANADA.—Quebec: Ile Perrot, on conifer, 10197. Ontario: Chaffey's Locks, on *Tsuga canadensis*, 9346; Matawatchan, on *T. canadensis*, F2275. British Columbia: Vancouver, on *T. heterophylla*, F569.

CULTURAL CHARACTERS: (Pl. V, Fig. 5; Pl. VI, Figs. 17 to 20).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, hyaline, submerged or appressed. Mat white at first and remaining so or developing scattered, more or less extensive, colored areas—"mustard yellow" (2.0Y 7.8/7.5), "primuline yellow" (1.5Y7.5/9.5), "chamois" (2.0Y7.5/5.8), "honey yellow" (2.0Y6.7/6.2), and "buckthorn brown" (8.0YR4.8/6.5)—the white areas subfelty to felty, with farinaceous surface and scattered dots of more compact mycelium, the colored areas crustlike or lacking aerial mycelium and then with the whole surface glazed, all with conspicuous anastomosing and branching wrinkles and furrows cut into the agar and producing a veined appearance when viewed through the agar. Reverse "honey yellow" (2.0Y6.7/6.2), sometimes bleached in part. Odor none. On gallic and tannic acid agars diffusion zones moderately strong, no growth on gallic acid agar, diameter 1.5–2.0 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently empty; (*b*) fiber hyphae, with walls thick and refractive, lumina narrow or apparently lacking, frequently branched, 1.5–4.0μ diameter; (*c*) cuticular cells, globose or subglobose, at first with contents staining in phloxine, then empty or with yellow or brown contents, closely packed to form a firm skin, cartilaginous in texture; (*d*) staghorn hyphae present in some isolates, apparently lacking in others. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, octahedral.

TYPE OF ROT: soft spongy white rot of dead coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

The cultural characters that have been used in separating *Ganoderma lucidum* and *G. Tsugae* are stated in the discussion under *G. lucidum*. Culturally these two species are sufficiently distinct not to coincide in the key, but *G. Tsugae* has the same key pattern as *G. oregonense* and *G. applanatum*, and it is difficult to separate them on the basis of cultural characters. Distribution and host are helpful, in that *G. Tsugae* is confined to eastern conifers, *G. oregonense* to western coniferous trees, and *G. applanatum*, while widely distributed, occurs more frequently on broad-leaved trees than on conifers.

Hymenochaete corrugata (Fries) Lév.

KEY PATTERN: (1,2) (1,2) 1 2 9 2 2 2 (1,2) 2 (1,2)

CULTURES EXAMINED:

UNITED STATES.—Locality and host not known, F2940, F2941.

CULTURAL CHARACTERS: (Pl. V, Fig. 6; Pl. VI, Figs. 21 and 22).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone variable, appressed or with raised aerial mycelium extending to limit of growth. Mat white or with scattered areas and lines "chamois" (2.0Y7.5/5.8) and "buckthorn brown" (8.0YR4.8/6.5) appearing after three to four weeks, slightly raised, woolly, at first thin and translucent, later thicker and opaque. Reverse unchanged or with irregular patches of "cinnamon-buff" (9.0YR6.6/5.8), "onion-skin pink" (2.0YR5.8/6.0), "pecan brown" (3.0YR4.7/4.5), to "walnut brown" (2.0YR3.8/3.5) appearing after three or more weeks. Odor sweet. On gallic acid agar diffusion zone strong, diameter up to 1.5 cm.; on tannic acid agar diffusion zone moderately strong, diameter 1.5–6.5 cm.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with rare simple septa, 3.0–6.0μ diameter. *Aerial mycelium:* hyphae as in advancing zone, but usually narrow, 1.5–2.2μ diameter. *Submerged mycelium:* hyphae as in advancing zone; (*b*) crystals numerous, octahedral.

TYPE OF ROT: white rot of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

Only two cultures of *Hymenochaete corrugata* were available for study, and they showed differences in color, rate of growth, and effect on agar. These possible variations, along with the occurrence on both broad-leaved and coniferous trees, necessitates the inclusion of 16 different key patterns for the species. In several instances these coincide with the key patterns for other species but it is hoped that separations can be made by means of the descriptive keys that have been included.

Hymenochaete tabacina (Sow. ex Fries) Lév.

KEY PATTERN: (1,2) 2 1 2 6 2 2 2 2 2 2

CULTURES EXAMINED:

CANADA.—British Columbia: Saanichton, on *Thuja plicata*, 9252, 9290.

CULTURAL CHARACTERS: (Pl. V, Fig. 7; Pl. VI, Figs. 23 to 26).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three weeks. Advancing zone even, hyaline, slightly raised aerial mycelium extending to limit of growth. Mat white (two weeks), with small areas becoming "Naples yellow" (3.0Y7.8/5.0), "fawn color" (4.0YR5.6/4.2), and "wood brown" (7.0YR5.7/4.0) (three weeks), these increasing in extent and changing to "vinaceous-fawn" (4.5YR6.7/3.5) and "brownish drab" (5.0R 5.7/2.0) (four to six weeks), slightly raised, downy to thin woolly to felty. Reverse unchanged or slightly darker below colored areas. Odor none. On gallic and tannic acid agars diffusion zones strong, diameter 1.0–1.5 cm. on gallic acid agar, 2.5–3.5 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, occasionally branched, with rare simple septa, 3.0–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently branched and anastomosed, 1.5–6.0μ diameter; (*b*) brown hyphae, with walls slightly thickened, branched, with simple septa, 2.2–4.5μ diameter; (*c*) brown hyphae with numerous irregular short branches, compactly interlocked to produce a firm pseudoparenchymatous layer. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

Cultures of *Hymenochaete tabacina* from broad-leaved trees have a key pattern that coincides with that for *Polyporus dryophilus* var. *vulpinus*. Cultures of the latter species have thick cottony mats, all colored except for a white border, and are, therefore, not to be confused with cultures of *Hymenochaete tabacina*.

Lentinus Kauffmanii Smith

KEY PATTERN: 2 1 (1,2) 3 9 2 2 2 (2,3) 2 2

CULTURES EXAMINED:

CANADA.—British Columbia: Prince George, on *Picea* sp., 17180; Queen Charlotte Islands, on *P. sitchensis*, F346, F443, F476, 10722, 10723, 11656, 11657, 11658, 11659, 11660, 11741, 11742, 16057, 16058, 16059. UNITED STATES.—Oregon: on *P. sitchensis*, 11684.

CULTURAL CHARACTERS: (Pl. V, Fig. 8; Pl. VI, Figs. 27 to 29).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to five weeks. Advancing zone even, hyaline and appressed in zone up to 1.0 cm. broad, the mycelium so scanty that limit of growth can be determined only by removing lid of Petri dish and examining surface of colony by reflected light. Mat white at first and remaining so or developing "pinkish buff" (9.0YR7.3/4.5) to "cinnamon-buff" (9.0YR6.6/5.8) areas after five to six weeks, appressed, downy to thin woolly, with numerous scattered compact dots or nodules, of which the surface is felty to smooth and skinlike, ranging from 1.0 mm. or less in diameter on young colonies up to 5.0–10.0 mm. on six-weeks-old cultures. Reverse unchanged. Odor strong, disagreeable. On gallic and tannic acid agars diffusion zones lacking or weak, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* leading hyphae hyaline, thin-walled, with inconspicuous simple septa, frequently branched, the branches soon developing clamp connections, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) nodose-septate hyphae as described above; (*b*) fiber hyphae numerous in older cultures, the walls thick and refractive, lumina narrow or apparently lacking except at tips, occasionally branched, 2.2–3.0μ diameter. *Submerged mycelium:* (*a*) nodose-septate hyphae as described above; (*b*) crystals numerous, large, octahedral.

TYPE OF ROT: pocket dry rot of *Picea* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Bier and Nobles (30).

Cultures of this species, isolated from either rotted wood or fruit bodies, are remarkably uniform and readily recognizable. If the characteristic hyphae of the advancing zone are observed and included, then the key pattern does not coincide with that for any other species. To date, the fungus has been recorded on spruce along the Pacific Coast from California to the Queen Charlotte Islands, and in the Prince George district of British Columbia.

Lentinus lepideus Fries

KEY PATTERN: 2 1 (1,2) 3 9 1 2 2 2 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Chelsea, on stump, F627. Ontario: Ottawa, on buried wood, F1334. Manitoba: Winnipeg, F3446. UNITED STATES.—Locality and host not known, F371.

CULTURAL CHARACTERS: (Pl. V, Fig. 9; Pl. VI, Figs. 30 to 34).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, submerged and appressed mycelium extending 0.5–1.0 cm. beyond aerial mycelium. Mat white, at first appressed, downy to thin woolly, so thin as to be translucent, becoming slightly raised and more compact woolly in scattered dots or zones, these especially numerous around edge of Petri dish and near inoculum, suggesting immature fruit bodies, "cinnamon-buff" (9.0YR6.6/5.8) to "clay color" (10.0YR5.8/6.0). Reverse unchanged. Odor very strong and disagreeable. On gallic and tannic acid agars diffusion zones lacking or very weak, growth lacking or limited to a trace.

HYPHAL CHARACTERS.—*Advancing zone:* leading hyphae hyaline, with rare inconspicuous simple septa, frequently branched, the branches soon developing clamp connections, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae hyaline, uniform, nodose-septate, 1.5–4.5μ diameter; (*b*) fiber hyphae numerous in older cultures, with walls thick and refractive, aseptate, unbranched, 2.0–3.0μ diameter, long curving, tapering to a slender tip; (*c*) chlamydospores rare to fairly numerous, walls relatively thick and not stained in phloxine, contents deeply stained, globose to broadly ovoid, 10.5–16.5 × 7.5–13.5μ. *Submerged mycelium:* (*a*) nodose-septate hyphae as in aerial mycelium, occasionally swollen up to 10.5μ diameter, with walls irregularly thickened and refractive; (*b*) chlamydospores as described for aerial mycelium; (*c*) crystals needlelike, often in clumps.

TYPE OF ROT: brown cubical rot of coniferous trees, especially *Pinus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (51, 54, 56), Davidson, Campbell, and Blaisdell (64), Davidson, Lombard, and Hirt (68), Snell (138), Walek-Czernecka (150).

Cultures of this species are similar to those of *Lentinus Kauffmanii*, the presence of chlamydospores on cultures of *L. lepideus* and their absence in *L. Kauffmanii* being the only means of separation. As with *L. Kauffmanii*, if the character of the hyphae of the advancing zone is observed and included in the key pattern, then the species does not coincide with any other in the key.

Lentinus tigrinus Bull. ex Fries

KEY PATTERN: 1 (1,2) 1 1 9 1 2 2 2 2 2

CULTURES EXAMINED:

CANADA.—Ontario: Locality and host unknown, F1349. UNITED STATES.—Locality and host not known, F3048.

CULTURAL CHARACTERS: (Pl. V, Fig. 10; Pl. VI, Figs. 35 and 36).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three weeks. Advancing zone even, hyaline and appressed, or with aerial mycelium uniform to limit of growth. Mat white and remaining so or becoming "yellow ocher" (10.0YR6.8/9.0), "tawny-olive" (8.0YR4.8/5.8), and "sayal brown" (7.0YR5.0/5.5) around inoculum, appressed, at first downy, then fine woolly, with few scattered compact lumps, especially against side of Petri dish in vicinity of inoculum, which may develop into short stipes of abortive fruit bodies (four to six weeks). Reverse unchanged. Odor strong, sharp, and penetrating. On gallic and tannic acid agars diffusion zones strong, diameter trace to 1.5 cm. on gallic acid agar, 1.5–2.0 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores numerous, terminal and intercalary, thin-walled, 7.5–12.0 × 6.0–9.0μ. *Submerged mycelium:* (*a*) hyphae and (*b*) chlamydospores as described above.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright and Findlay (51, 56), Davidson, Campbell, and Blaisdell (64), Snell (139).

The key patterns for *Lentinus tigrinus* coincide with those of several other species, but its thin woolly mat and the common formation of fruit body fundaments should serve to distinguish cultures of *L. tigrinus* from other species.

Lenzites betulina L. ex Fries

KEY PATTERN: (1,2) 1 1 1 9 2 2 2 (1,2) 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Iberville, on *Fagus grandifolia*, F8021; Montreal, on *Betula* sp., 10199. UNITED STATES.—Host and locality not known, F2171.

CULTURAL CHARACTERS: (Pl. V, Fig. 2; Pl. VI, Figs. 37 and 38).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to four weeks. Advancing zone even, in some isolates hyaline and appressed in narrow zone so that it is difficult to see limit of growth, in others with the slightly raised aerial mycelium extending to limit of growth. Mat white, the newest growth slightly raised, floccose-woolly, becoming patchy, with some areas raised, plateaulike, felty-woolly, very tough, the intervening areas appressed, thin felty, all peeling readily from agar, the mycelium frequently grown up sides and down between lid and base of Petri dish. Reverse unchanged. Odor lacking or slight. On gallic and tannic acid agars diffusion zones strong, no growth or only a trace on gallic acid agar, diameter 1.5–3.5 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae very numerous, with walls thick and refractive, lumina narrow or apparently lacking, aseptate, occasionally branched, 1.5–3.0μ diameter. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) fiber hyphae as in aerial mycelium.

TYPE OF ROT: white rot of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Brodie (37), Cartwright and Findlay (52, 56), Davidson, Campbell, and Blaisdell (64), Vandendries (142, 143), Vandendries and Brodie (147, 148).

Lenzites betulina has key patterns identical with those of several other species, which makes its recognition in culture difficult. However, in all the cultures examined, nonstaining fiber hyphae were as plentiful in the submerged mycelium as in aerial mycelium, a condition that was not observed in other species. It is hoped that this will prove to be of diagnostic value.

Lenzites saepiaria Wulf. ex Fries

KEY PATTERN: (1,2) 2 2 1 9 (1,2) 2 1 (2,3,4) 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Eagle Depot, on *Pinus Banksiana*, 9528. Ontario: Chalk River, on *Picea glauca*, F3250; Petawawa, on *P. mariana*, 9419. UNITED STATES.—Wisconsin: Rothchild, on *Tsuga* sp., F715. Locality and host not known, F2172. GERMANY.—Eberswalde, on *Pinus sylvestris*, F1007.

CULTURAL CHARACTERS: (Pl. V, Fig. 12; Pl. VI, Figs. 39 to 41).

GROWTH CHARACTERS.—Growth moderately slow to very slow, plates covered in four to seven weeks. Advancing zone somewhat bayed, appressed and hyaline in zone 1.0–2.0 mm. broad. Mat white for two to three weeks, then with patches or zones of "chamois" (2.0Y 7.5/5.8), "honey yellow" (2.0Y6.7/6.2), "tawny-olive" (8.0YR4.8/5.8) (three to four weeks), to "snuff brown" (7.0YR3.9/3.5) (four to six weeks), at first slightly raised, cottony, but soon collapsed, farinaceous, appearing patchy by reason of variations in color and amount of aerial mycelium. Reverse unchanged or somewhat darker below colored areas. Odor slightly spicy. On gallic and tannic acid agars no diffusion zones, trace of growth up to 2.5 cm. diameter on gallic acid agar, no growth or only a trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, but soon broken up to form oidia; (*b*) oidia very numerous, cylindric, frequently with swollen portion, or broadly ovoid, often with fragment of clamp connection attached, 5.0–22.0 $\times$ 2.5–4.5μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores rare or apparently lacking, terminal or intercalary, thin-walled, 7.5–16.5 $\times$ 5.0–9.0μ; (*c*) crystals platelike or needlelike.

TYPE OF ROT: brown pocket rot of coniferous or, rarely, broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright (47), Cartwright and Findlay (51, 54, 56), Davidson, Campbell, and Blaisdell (64), Davidson, Lombard, and Hirt (68), Fries (73), Fritz (74), Humphrey and Siggers (92), Mounce and Macrae (113), Robak (133, 134), Snell (138, 139), Snell, Hutchinson, and Newton (140).

In *Lenzites saepiaria*, the nodose-septate hyphae undergo fragmentation to form oidia. In other species having the same key pattern, oidium formation is restricted to hyphae with simple septa in those portions of the colony that have reverted to a haploid condition. This characteristic makes possible the separation of cultures of *L. saepiaria* from similar species.

Lenzites trabea Pers. ex Fries

KEY PATTERN: (1,2) 2 2 1 9 1 2 1 2 1 2

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, on lumber from broad-leaved tree, F3823; Toronto, on *Tsuga canadensis*, 9507. UNITED STATES.—Locality and host not known, F3050.

CULTURAL CHARACTERS: (Pl. V, Fig. 13; Pl. VI, Figs. 42 to 46).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, slightly raised aerial mycelium extending to limit of growth. Mat white at first, slightly raised, cottony to woolly, loosely arranged (one week), the older part changing to "cream color" (3.0Y8.6/4.5), "cream-buff" (3.0Y8.3/4.5), "warm buff" (1.2Y7.8/6.0), "chamois" (2.0Y7.5/5.8), and "cinnamon-buff" (9.0YR6.6/5.8), cottony-

floccose to woolly, with overgrowth of granular or irregularly pored fruiting surface, "tawny-olive" (8.0YR4.8/5.8) (two weeks), the raised cottony mycelium developing more vivid tones of "pinkish cinnamon" (6.0YR6.5/5.5) and "cinnamon" (5.0YR5.8/6.0) or "buff-yellow" (2.0Y7.9/7.0) to "pale orange-yellow" (1.0Y8.3/6.2), mostly overgrown with irregularly pored or toothed fruiting surface, "Sudan brown" (5.5YR3.8/5.5) and "Brussels brown" (5.0YR3.5/4.0) in color, frequently with brightly colored mycelium grown up side of Petri dish and down between base and lid. Reverse unchanged. Odor very strong, suggesting garlic. On gallic and tannic acid agars no diffusion zones, diameter 2.0 cm. on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, the clamp connections large and conspicuous, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae rare except in fruiting surface, hyaline to buffy brown, with walls thick and refractive except for thin-walled tips, aseptate, rarely branched, 2.2–3.5μ diameter; (*c*) oidia numerous, formed by fragmentation of nodose-septate hyphae, 2.2–3.0μ diameter, variable in length. *Fruit body:* (*a*) nodose-septate hyphae and (*b*) fiber hyphae as described above; (*c*) basidia 5.0–6.0μ diameter, bearing four spores; (*d*) basidiospores hyaline, even, cylindric, flattened on one side, 9.0–12.0 × 3.0–4.5μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores numerous, ovoid to ellipsoid or elongate, intercalary or terminal, with thin walls and contents staining deeply in phloxine, 10.5–18.0(–28.0) × 6.0–10.5μ.

TYPE OF ROT: brown cubical rot of coniferous and broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright (49), Cartwright and Findlay (52, 54, 56), Davidson, Campbell, and Blaisdell (64), Davidson, Lombard, and Hirt (68), Humphrey and Siggers (92), Kaufert and Schmitz (94), Mounce and Macrae (113), Snell (138).

The distinctive color, the production of chlamydospores and oidia, and the early fruiting are characteristics that make the key patterns of *Lenzites trabea* unique, and the identification of cultures of the species relatively easy.

Merulius lacrymans Jacq. ex Fries

KEY PATTERNS: 2 (1,2) 2 1 9 2 2 2 3 2 2 or
2 (1,2) 2 2 9 2 2 1 4 2 2 ("oidial strain")

CULTURES EXAMINED:

CANADA.—Quebec: Montcalm, below wooden floor, F3526. Ontario: Ottawa, on beam in cellar, F1606. ENGLAND.—Locality and host not known, F7328, 8787.

CULTURAL CHARACTERS: (Pl. V, Figs. 14, 15; Pl. VI, Figs. 48 to 50).

GROWTH CHARACTERS.—Growth slow, plates covered in five to six weeks. Advancing zone even or with fans of mycelium extending along edge of Petri dish in advance of mat proper, and then growing in to meet advancing periphery, raised aerial mycelium extending to limit of growth. Mat white at first, then developing patches of "barium yellow" (8.0Y8.0/6.5), "citron yellow" (7.0Y8.0/7.5), and "strontian yellow" (7.0Y8.3/9.0) (three weeks) to "Isabella color" (1.0Y5.5/4.3) (five weeks), slightly raised, silky, then cottony-woolly, with small strands radiating from inoculum over surface of mat and expanding in fanlike arrangement at margin, or with strands grown up sides of Petri dish and over inner surface of cover. Reverse unchanged. Odor strong. On gallic and tannic acid agars no diffusion zones, diameter of colony 1.5–2.0 cm. on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae nodose-septate, 4.5–6.0μ diameter. *Aerial mycelium:* hyphae as in advancing zone, 3.0–7.5μ diameter. *Submerged mycelium:* (*a*) hyphae as in advancing zone, but usually narrower, 2.2–3.5μ diameter; (*b*) crystals numerous, octahedral.

TYPE OF ROT: brown cubical rot of coniferous wood.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (51, 52, 54, 56), Edgecombe (69), Humphrey and Siggers (92).

The foregoing description of *Merulius lacrymans* is based on only one culture, 8787, which grew as described when first examined in 1939, but which had changed when re-examined in 1942. At the later date it resembled the other cultures of *M. lacrymans* in the collection, all of which had reverted to the haploid condition, characterized by a very slow rate of growth, the radius of the colony being 2.0 cm. or less in six weeks, by the absence of clamp connections on all the hyphae, and by the production of numerous oidia. Cartwright and Findlay (54) quote Falck as having observed a similar change in old cultures of this species, "especially if the culture had been kept for long periods at a temperature above the optimum". The species is included in both the white and colored sections of the key, although the colors are probably always sufficiently deep to warrant its inclusion in the latter group only. Among the colored forms no other species has a key pattern identical with that for *M. lacrymans*. If it is considered as belonging to the white group, with nodose-septate hyphae, then it falls with several other species, from which *M. lacrymans* should be readily separable by reason of its consistent production of vivid yellow patches of mycelium and by its plumose growth. The haploid strain, whether taken as white or colored, stands alone in the key.

Omphalia campanella Fries

KEY PATTERN: 2 2 1 1 6 2 2 2 4 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Lac Vert, on *Abies balsamea*, 10299, on *Picea mariana*, 10298. British Columbia: Big Bend, on *Thuja plicata*, 16124; Clearwater, on *T. plicata*, 16123; Copper Canyon, on *T. plicata*, 16120; Fanny Bay, on *T. plicata*, 16122; Hidden Lake, on *T. plicata*, 11980, 16170, 16622; Port Alberni, on *T. plicata*, 16121; Queen Charlotte Islands, on *Picea sitchensis*, 11981, 11982. UNITED STATES.—On *Thuja plicata*, 11761.

CULTURAL CHARACTERS: (Pl. VII, Fig. 1; Pl. VI, Figs. 51 to 53).

GROWTH CHARACTERS.—Growth very slow, radius 5.0–7.0 cm. in six weeks. Advancing zone even, hyaline and appressed in narrow zone. Mat appressed, at first white, sodden, with sparse aerial mycelium, or cottony-floccose, developing sharply contrasting areas or zones (two to three weeks), crustose, "buckthorn brown" (8.0YR4.8/6.5), "mummy brown" (7.5YR2.5/2.3), and "burnt umber" (2.0YR2.5/2.5), usually with a narrow "ochraceous-tawny" (6.0YR4.9/6.3) border, and with a thin floccose overgrowth of frosty white, from which arise numerous 'aerial rhizomorphs' concolorous with the crustose surface except for whitish tips and "Mars yellow" (6.0YR5.3/10.3) to "Sudan brown" (5.5YR3.8/5.5) tufts of mycelium at their bases, branched, extending into air or meeting surface of agar in advance of mat proper and there developing a velvety brown mycelium that soon produces growth typical of a young colony. Reverse unchanged. Odor none. On gallic and tannic acid agars diffusion zones moderately strong to strong, trace of growth on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) nodose-septate hyphae as in advancing zone; (*b*) in crustose areas hyphae at first hyaline with contents stained in phloxine, then brown and apparently empty, with numerous irregular branches and projections so tightly interlocked that outlines of component parts are lost; (*c*) conspicuous dark brown hyphae, thick-walled, nodose-septate, 2.2–4.5μ diameter, with swellings up to 18.0μ diameter. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: The formation of brown diffusion zones on media containing gallic or tannic acids by cultures of *Omphalia campanella* suggests that this species produces a white rot, but definite information on this is not available. Buckland (38) states that all of his isolations of *O. campanella* from *Thuja plicata* were from mixed rots, in which it was impossible to determine whether this fungus was the primary cause of decay or only secondary. It is known to occur only on coniferous trees.

If the pseudoparenchymatous layer in *Omphalia campanella* is interpreted as being composed of hyphae with interlocking projections, and listed as "6" under special structures, then the key pattern for this species does not coincide with that for any other species. When it is once known, the purplish-brown crustose areas bristling with the unique 'aerial rhizomorphs' make this one of the most readily recognized species.

Peniophora gigantea (Fries) Massee

KEY PATTERN: 2 1 (1,2) 2 9 2 2 1 (1,2) 2 2

CULTURES EXAMINED:

Locality and host not known, F7329, 10249.

CULTURAL CHARACTERS: (Pl. VII, Fig. 2; Pl. VIII, Figs. 1 and 2).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone even, hyaline, appressed. Mat white, all submerged with no aerial mycelium or appressed floccose-farinaceous in more or less extensive areas. Reverse unchanged. Odor strong, penetrating. On gallic acid agar diffusion zones weak to strong, diameter 1.0–2.0 cm.; on tannic acid agar no diffusion zone, no growth.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, the septa usually simple but rarely with large clamp connections, branched, the branch constricted at point of attachment, 2.2–6.0μ diameter. *Surface mycelium:* (*a*) hyphae as in advancing zone; (*b*) oidia numerous almost to limit of growth, 2.2–4.5μ diameter and of varying lengths. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: pale yellowish-brown rot in sapwood of coniferous logs and worked lumber, according to Cartwright and Findlay (54).

DESCRIPTIONS OF CULTURAL CHARACTERS: Biggs (31), Cartwright and Findlay (54, 56), Davidson, Campbell, and Blaisdell (64), Humphrey and Siggers (92).

Clamp connections are so rare in this species that they have been ignored in preparing the key pattern. Three of the four key patterns that must be assigned to the species differ from the patterns for all other species, but one, showing negative reaction on gallic and tannic acid agars and a slower rate of growth, coincides with the key pattern for *Trametes americana*. Among other differences between these two species, the positive reaction of *Peniophora gigantea* on gallic acid agar and negative reaction on tannic acid agar distinguishes it from *Trametes americana*, which shows a negative reaction on both media.

Pholiota adiposa Fries

KEY PATTERN: (1,2) (1,2) 1 1 9 2 1 2 (2,3) 2 2

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, on *Acer* sp., F969. British Columbia: Aleza Lake, on *Abies lasiocarpa*, 16580; Saanich, on *Abies* sp., 8179, on *Pseudotsuga taxifolia*, 8297; Shawnigan Lake, on *Abies grandis*, 8457. ENGLAND.—Locality and host not known, F1281.

CULTURAL CHARACTERS: (Pl. VII, Fig. 3; Pl. VIII, Figs. 3 to 6).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to five weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white at first, then with tinges of "pale olive-buff" (5.0Y8.2/2.5) to "deep olive-buff" (4.0Y6.7/3.8) (three to four weeks), these greenish-yellow tones changing to yellow—"primrose yellow" (7.0Y8.5/5.2), "colonial buff" (6.0Y8.5/5.5), and "chamois" (2.0Y 7.5/5.8)—in older cultures, at first slightly raised, cottony to woolly, lacunose, becoming collapsed and woolly, with branching and anastomosing strands, deeper in color than surrounding mycelium, conspicuous in vicinity of inoculum. Reverse unchanged in color, with strands in agar prominent. Odor fairly strong, "earthy" (Badcock), like freshly autoclaved soil. On gallic acid agar diffusion zones strong, no growth; on tannic acid agar diffusion zones weak, no growth or only a trace.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, occasionally deep yellow in potassium hydroxide; (*b*) conidiophores numerous, each being the end of a hypha or short lateral branch, conspicuous by reason of its increased diameter and dense content staining deeply in phloxine, from which the end is cut off by a simple septum to form a conidium, below which the conidiophore may proliferate to produce a branch and second conidium, this continuing until a small fascicle of conidia is formed; (*c*) conidia plentiful, thin-walled, hyaline to yellow, with dense granular contents, variable in size and shape but typically cylindric with proximal end straight and distal end rounded, 5.4–11.7 × 2.7–5.4μ; (*d*) crystals plentiful, needlelike. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: brown mottled rot of heartwood of living broad-leaved or, more rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Davidson, Campbell, and Vaughn (67), Edgecombe (69), Mounce (108).

The cultural characters of *Pholiota adiposa* set it apart from all other species included in the present study, but they show it to be similar to *P. aurivella* as described by Martens and Vandendries (104), and as observed in a culture of that species received from the Centraalbureau voor Schimmelcultures at Baarn. Additional studies are necessary to establish a basis for separating these species. One of the key patterns for *P. adiposa* is the same as that for *Polyporus rutilans* but the conidiophores and conidia in the two species are so distinctive as to allow for ready separation.

Pleurotus ostreatus Jacq. ex Fries

KEY PATTERN: (1,2) 1 (1,2) 1 9 2 2 2 2 (1,2) 2

CULTURES EXAMINED:

CANADA.—Ontario: Malakoff, on *Polyporus* sp., 9220; Ottawa, on *Salix* sp., F2503. UNITED STATES.—Locality and host not known, F2949.

CULTURAL CHARACTERS: (Pl. VII, Fig. 4; Pl. VIII, Figs. 7 to 9).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white, slightly raised,

cottony in newest growth, then collapsed, woolly-felty, with slightly raised tufts arranged in more or less concentric zones, producing somewhat zonate appearance, and with small masses of compactly arranged mycelium around edge of Petri dish in some isolates, from which may develop abortive or, occasionally, mature but distorted fruit bodies. Reverse unchanged or bleached after three to four weeks. Odor slight, fragrant. On gallic acid agar diffusion zones moderately strong, on tannic acid agar no diffusion zones, no growth on either medium. (See Davidson, Campbell, and Blaisdell (64).)

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 2.2–7.5μ diameter, usually broad. *Aerial mycelium:* (*a*) hyphae as in advancing zone, usually 2.2–4.5μ diameter, frequently broken up into short segments; (*b*) fiber hyphae, with walls thick and refractive, the lumina visible only at bases of branches, frequently branched, 1.5–2.2μ diameter. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white flaky rot of sapwood and heartwood of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (52, 55, 56), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Edgecombe (69), Humphrey and Siggers (92).

The three isolates of *Pleurotus ostreatus* used in this study all gave positive reactions on gallic acid agar, negative reactions on tannic acid agar, but Davidson, Campbell, and Blaisdell (64), using a larger number of cultures, found the most usual reaction on tannic acid agar was a positive one, agreeing with the positive reaction on gallic acid agar. In each of the eight places in which *P. ostreatus* appears in the key it falls with several other species with identical key patterns. In these cases separations can be made only on the basis of differences in macroscopic cultural characters.

Pleurotus ulmarius Bull. ex Fries

KEY PATTERN: 1 1 2 1 9 2 2 2 (3,4) 2 2

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, on *Acer Negundo*, F326, F2418.

CULTURAL CHARACTERS: (Pl. VII, Fig. 5; Pl. VIII, Fig. 10).

GROWTH CHARACTERS.—Growth slow to very slow, plates covered or radius only 5.0–8.5 cm. in six weeks. Advancing zone even to somewhat bayed, raised aerial mycelium extending to limit of growth. Mat white or very pale "cream color" (3.0Y8.6/4.5) or "cartridge buff" (3.0Y8.5/2.2), raised, loosely arranged, cottony, tangled, sometimes with small drops of colorless exudate over surface. Reverse unchanged. Odor slightly fragrant. On gallic and tannic acid agars no diffusion zones, no growth.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, branched, usually between septa, 1.5–3.0μ diameter. *Aerial and submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: brown rot of living broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Davidson, Campbell, and Blaisdell (64), Edgecombe (69).

The faster growing cultures of *Pleurotus ulmarius* have a key pattern identical with those for several other species. The loosely arranged, tangled, cottony mat, and lack of growth on media containing gallic and tannic acids make cultures of *P. ulmarius* distinguishable from those of other species in the group.

Polyporus abietinus Dicks. ex Fries

KEY PATTERN: (1,2) 1 1 1 1 2 2 2 2 2 2

CULTURES EXAMINED:

CANADA.—Prince Edward Island: on *Abies balsamea*, F704. Quebec: Alex River, on *A. balsamea*, 11592, 11593, on *Picea mariana*, 11595; Chelsea, on *Pinus Strobus*, F5886; Eagle Depot, on *Larix laricina*, F7072; Lac Vert, on *Abies balsamea*, 10291, on *Picea mariana*, 10289, 10290. Ontario: Ottawa, on *Pinus* sp., F6893. UNITED STATES.—New York: Tupper Lake, on *Picea* sp., F7425. Pennsylvania: Bear Creek, on *Pinus* sp., F1651. Locality and host not known, F380. NORWAY.—Oslo, on *Pinus sylvestris*, F7379.

CULTURAL CHARACTERS: (Pl. VII, Fig. 6; Pl. VIII, Figs. 11 to 14).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, hyaline and appressed in narrow zone. Mat white, in all isolates except F7072 appressed, sparse cottony-floccose to woolly, so thin as to be translucent, frequently with more compact woolly growth in short radiating lines over surface; in F7072 mat raised, cottony, thick enough to be opaque, with surface spongy or honeycombed. Reverse unchanged. No odor. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 1.5–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone making up most of mat; (*b*) fiber hyphae with walls thick and refractive, lumina narrow or apparently lacking, 3.0–4.0μ diameter, rare or apparently lacking in some isolates, plentiful in F7072; (*c*) capitate incrusted cystidia numerous, each consisting of a slightly swollen hyphal tip bearing a cap of crystals. *Submerged mycelium:* hypae as in advancing zone, usually much branched.

TYPE OF ROT: white pocket rot of coniferous or, rarely, broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright and Findlay (54, 56), Davidson, Campbell, and Blaisdell (64), Fritz (74), Garren (75, 76), Humphrey and Siggers (92), Macrae (103), Robak (133, 134).

Host preferences of *Polyporus abietinus* for coniferous trees and of *P. pargamenus* for broad-leaved trees should be helpful in separating cultures of these similar species, but since both species may occur on both types of hosts other diagnostic characters are needed. The abundance of fiber hyphae in all cultures of *P. pargamenus* and their relative scarcity or apparent absence in most cultures of *P. abietinus* provide the most useful criterion for separation. Caution must be used, however, since one isolate of *P. abietinus* had numerous fiber hyphae and the general appearance of cultures of *P. pargamenus*. This isolate, F7072, was obtained from a lamellate fruit body of *P. abietinus* and monosporous cultures of it were interfertile with other isolates from the lamellate form and, in part, with two isolates of the European poroid form (Macrae (103)). Hence it must be accepted as a culture of *P. abietinus* and its type of growth may be expected in cultures of the species. Thus no definite basis for separating these species in culture is so far available, but in general, cultures with this key pattern from coniferous hosts, showing little aerial mycelium and no or rare fiber hyphae, may be safely assigned to *P. abietinus*.

Polyporus adustus Willd. ex Fries

KEY PATTERN: (1,2) 1 2 1 9 2 2 (1,2) 1 2 (2,3)

CULTURES EXAMINED:

CANADA.—Quebec: Chelsea, on *Fagus grandifolia*, 9208, 9209, on dead stub, 11606; Chute à Blondeau, on *Ulmus americana*, F2271. Ontario: Ottawa, on *Tilia americana*, F1391. UNITED STATES.—Locality and host not known, F2951.

CULTURAL CHARACTERS: (Pl. VII, Fig. 6; Pl. VIII, Figs. 15 to 18).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, slightly raised aerial mycelium extending to limit of growth. Mat white or with tinge of "cream-buff" (3.0Y8.3/4.5) after three to four weeks, cottony-woolly to woolly-floccose in newest growth, finally collapsed and felty, in some isolates so thin as to be translucent. Reverse unchanged or bleached after three to four weeks. Odor slight, "faintly fragrant". On gallic acid agar diffusion zones lacking (may be slight browning of agar), diameter 1.5–3.5 cm.; on tannic acid agar no diffusion zones, no growth.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, profusely branched, 2.2–4.5(–6.0)μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) oidia formed by fragmentation of nodose-septate hyphae or of branches with simple septa, 2.2–3.0μ diameter, of lengths varying from 2.0–15.0μ. *Submerged mycelium:* hyphae as in advancing zone, frequently irregular, with numerous short branches, projections, and swellings.

TYPE OF ROT: white mottled or cubical rot of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Bose (32), Cartwright (49), Cartwright and Findlay (51, 56), Davidson, Campbell, and Blaisdell (64), Vandendries (144).

This differs from other descriptions of the species, which have omitted mention of oidia or have described them as being restricted to monosporous cultures (Vandendries (144)), and have reported the occurrence of chlamydospores (Cartwright (49)) and of conidia (Bose (32)). In the present study oidia in abundance were observed on nodose-septate hyphae in five of the isolates examined. The remaining isolate (9208) appeared to have lost vigor, in that it produced almost no aerial mycelium and, perhaps correlated with this, no oidia. The other types of secondary spores reported by Cartwright (49) and Bose (32) were not observed, although this apparent discrepancy may be the result of differences in interpretation of the method by which the spores are produced rather than of actual differences in the cultures.

If oidia are observed and their presence included, then the key pattern of *P. adustus* is different from that of any other species. If oidia are omitted, then its key pattern coincides with those for *P. betulinus* and *P. dichrous*, from which separations can be made only on the basis of differences in topography and in the degree of inhibition of growth by gallic and tannic acid agars.

Polyporus albellus Peck

KEY PATTERN: 1 1 1 1 (0,9) 1 2 2 2 (1,2) 2

CULTURES EXAMINED:

CANADA.—Quebec: Chelsea, on *Fagus grandifolia*, F7532; Mt. Burnet, on *Betula lutea*, F6850. Ontario: Caledon East, on *B. lutea*, 10237; Centreton,

on *Betula* sp., 8484; Ottawa, on *B. lutea*, F1394; Petawawa, on *Alnus incana*, 11608.

CULTURAL CHARACTERS: (Pl. VII, Fig. 8; Pl. VIII, Figs. 19 to 21).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three weeks. Advancing zone even, hyaline, and appressed or with slightly raised aerial mycelium extending to limit of growth. Mat white, downy at first, after two to three weeks forming overgrowths of cottony-woolly mycelium in loosely arranged balls around inoculum, gradually extending over surface in more or less concentric arrangement, many of the balls becoming waxy and bearing minutely pored fruiting surfaces after four to five weeks. Reverse unchanged. Odor strong and penetrating but not identified. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, trace to 1.0 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) contorted hyphal tips, heavily incrusted, conspicuous in mounts, up to 7.0μ diameter; (*c*) chlamydospores fairly numerous, thin-walled, with contents deeply stained in phloxine, terminal or intercalary, 6.0–12.0 × 4.5–7.0μ. *Fruit body:* (*a*) basidia 4.0–5.0μ diameter, bearing four spores; (*b*) basidiospores hyaline, even, allantoid, 3.0–4.0 × 1.5μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores as in aerial mycelium.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

If the characteristic contorted hyphal tips in cultures of *Polyporus albellus* are recognized and included in the key pattern, then this species falls alone in the key and is readily recognized. If they are omitted, then the key pattern for *P. albellus* coincides with those for several other species, and separation can be made only by considering the whole complex of characters making up each species within the group.

Polyporus amorphus Fries

KEY PATTERN: 2 1 1 1 (7,9) 2 2 2 4 (1,2) 2

CULTURES EXAMINED:

CANADA.—Quebec: Eagle Depot, on *Pinus Banksiana*, 8550, 8552.

CULTURAL CHARACTERS: (Pl. VII, Fig. 9; Pl. VIII, Figs. 22 to 24).

GROWTH CHARACTERS.—Growth very slow, radius 3.0–4.0 cm. in six weeks. Advancing zone even, appressed and hyaline in zone 2.0–5.0 mm. wide. Mat white, appressed to slightly raised, compact felty to velvety, with surface somewhat farinaceous, becoming irregularly pored in some isolates. Reverse unchanged. Odor strong, sour. On gallic and tannic acid agars diffusion zones moderately strong to strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, regular in appearance, nodose-septate, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, walls thick and refractive, lumina narrow or apparently lacking, unbranched, aseptate, 3.0–4.5μ diameter. *Fruit body:* (*a*) basidia in organized hymenium or in clumps over surface, usually with oily contents that flow from injured cells and obscure mount, 4.0–5.0μ diameter, bearing four spores; (*b*) basidiospores hyaline, even, allantoid, 4.0 × 1.5μ. *Submerged mycelium:* hyphae as in advancing zone, frequently with swellings up to 10.0μ diameter, at first staining deeply in phloxine, then appearing empty and collapsed.

TYPE OF ROT: brown stringy rot of coniferous trees.

Whether or not the swollen cells that occur in the submerged mycelium of *Polyporus amorphus* cultures are included, the key patterns of the species are different from all others in the study. Hence no difficulty should be encountered in recognizing cultures of this species.

Polyporus anceps Peck

KEY PATTERN: 2 1 1 1 9 2 2 2 1 1 2

CULTURES EXAMINED:

CANADA.—Quebec: Aylmer, on *Pinus* sp., F2064. Ontario: Chalk River, on *P. Banksiana*, F3372, F3445; Petawawa, on *Picea* sp., 10213; Port Alexander, on log, 10220. British Columbia: Yellow Point, on *Pseudotsuga taxifolia*, 8264.

CULTURAL CHARACTERS: (Pl. VII, Fig. 10; Pl. VIII, Figs. 25 to 28).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white, newest growth raised, cottony-woolly, spongy, becoming appressed and felty in part, with more or less extensive fruiting surfaces formed after two to six weeks, consisting of small compact pored areas or broad zones covered with irregular pores or teeth. Reverse unchanged. Odor none. On gallic and tannic acid agars diffusion zones strong, no growth or only a trace on gallic acid agar, trace to 2.5 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 2.2–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, with walls thick and refractive, lumina narrow or apparently lacking, frequently branched, aseptate, 1.0–2.0(–3.0)μ diameter, curving and interwoven to form mat and fruiting surface; (*c*) dendritically branched hyphae found in F3445 only, mostly in the fruiting area. *Fruit body:* (*a*) nodose-septate hyphae and (*b*) fiber hyphae as described above; (*c*) basidia plentiful even in young cultures, occurring singly, in groups, or in organized hymenium, 6.0–7.5μ diameter, bearing four spores; (*d*) basidiospores hyaline, even, cylindric, 7.5–10.0 × 2.2–3.0μ. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white pocket rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Baxter and Manis (25), Davidson, Campbell, and Blaisdell (64), Mounce (110).

The six isolates of *Polyporus anceps* proved to be so uniform in their cultural characters as to require only one key pattern. This is identical with one of the key patterns for *P. hirsutus*, which, however, is found only rarely on coniferous trees, the exclusive habitat of *P. anceps*. Among the distinguishing characters of the two species, the greater length of the basidiospores of *P. anceps* is the most precise.

Polyporus arcularius Batsch ex Fries

KEY PATTERN: 1 2 1 1 6 (1,2) 2 2 1 2 (2,3)

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, under *Salix* sp., 10447.

CULTURAL CHARACTERS: (Pl. VII, Fig. 11; Pl. VIII, Figs. 29 to 32).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, hyaline and appressed in narrow zone. Mat white (one week), becoming "light brownish drab" (2.0YR4.7/1.8), "avellaneous" (8.0YR6.2/3.5), "vinaceous-fawn" (4.5YR6.7/3.5), with islands remaining white (two weeks), finally "light cinnamon-drab" (2.0YR5.8/1.8), "benzo brown" (2.5YR4.4/1.5), "light brownish drab" (2.0YR4.7/1.8), and "vinaceous-drab" (10.0RP4.7/2.0), mottled, with some areas that remain white, the white parts slightly raised, woolly-felty, the colored areas felty to skinlike, brittle or cartilaginous, wrinkled. Reverse patchy, some areas bleached, remaining areas "honey yellow" (2.0Y6.7/6.2). Odor suggesting honey, and also yeasty. On gallic and tannic acid agars diffusion zones strong, trace of growth on gallic acid agar, 3.5 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous,

frequently branched, with walls thick and refractive, the lumina visible only at bases of branches, 1.5–3.0μ diameter; (*c*) hyphae from skinlike areas nodose-septate, the walls thickened so that lumina frequently disappear completely, buffy-brown in potassium hydroxide, with numerous short branches or knoblike projections, all interlocked to form a tissue so coherent that it is almost impossible to prepare mounts showing individual elements; (*d*) chlamydospores rare or apparently lacking, intercalary and terminal, thin-walled, 9.0–13.5 × 6.0–7.5μ. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as described above.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Refshauge and Proctor (128), Vandendries (145).

This description is based on only one culture, which was isolated from a fruit body having the large pores typical of *Polyporus arcularius*. It resembles closely the cultures of *P. brumalis*, the key patterns of the two species being identical. The one culture of *P. arcularius* available appears to have distinct vinaceous tones and to be darker in color than the cultures of *P. brumalis* but this does not provide a satisfactory basis of separation. A further comparison of these two species in culture is necessary.

Polyporus balsameus Peck

KEY PATTERN: 2 1 2 1 9 1 2 2 (2,3) (1,2) (1,2)

CULTURES EXAMINED:

CANADA.—Quebec: Champlain County, on *Picea mariana*, 10279; Gaspé County, on *Abies balsamea*, F936; Mt. Burnet, on *A. balsamea*, F5624. British Columbia: Aleza Lake, on *A. lasiocarpa*, 16582; Oyster River, on *Tsuga heterophylla*, 8407.

CULTURAL CHARACTERS: (Pl. VII, Fig. 12; Pl. VIII, Figs. 33 to 35).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to six weeks. Advancing zone even, hyaline and appressed in zone up to 0.5 cm. wide. Mat white at first and remaining so for six weeks or changing to "pinkish buff" (9.0YR7.3/4.5) and "cinnamon" (5.0YR5.8/6.0) in older parts after three to six weeks, cottony, with mycelium erect, loosely interwoven, becoming coarse plumose or tufted in older part and around edge, or with aerial mycelium scanty, appressed, downy, in F936 forming waxy pored surface. Reverse unchanged below white mats, "russet" (2.5YR4.0/3.0) to "cinnamon-brown" (5.0YR3.0/3.0) below colored areas. Odor strong, suggesting iodoform. On gallic and tannic acid agars no diffusion zones (may be slight browning on gallic acid agar), colony 1.5–3.0 cm. diameter on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–6.0(–7.5)μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores numerous, intercalary or terminal, the latter occurring singly or in spraylike clusters, when immature thin-walled, hyaline, with contents staining in phloxine, then thicker-walled with buffy-brown contents, 7.5–16.5 × 4.5–9.0μ. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as in aerial mycelium.

TYPE OF ROT: brown butt rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson and Campbell (63), Davidson, Campbell, and Blaisdell (64), Fritz (74), Hubert (90).

The chlamydospores with brown contents in *Polyporus balsameus* are unique, and serve to differentiate this species from all others included in the present study.

Polyporus Berkeleyi Fries

KEY PATTERN: (1,2) 1 1 2 9 1 (1,2) 2 3 (1,2) 2

CULTURES EXAMINED:

UNITED STATES.—North Carolina: host not known, F2175. Locality and host not known, F2952.

CULTURAL CHARACTERS: (Pl. VII, Fig. 13; Pl. VIII, Figs. 36 to 40).

GROWTH CHARACTERS.—Growth slow, plates covered in five weeks. Advancing zone even, hyaline and appressed in narrow zone. Mat white with tinge of "cinnamon-buff" (9.0YR 6.6/5.8) around inoculum (four weeks), the narrow outer zone downy, composed largely of erect conidiophores visible when examined under low magnification, the older part felty and skinlike, with many raised granules over surface, finally uniform, thick, tough, pellicular. Reverse unchanged. Odor strong. On gallic and tannic acid agars diffusion zones strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, branched, the branches usually forming a right angle with the parent hyphae, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae with walls thick and refractive, lumina narrow but visible and staining in phloxine, branched, with tapering ends, 1.5–3.0μ diameter, interwoven to form pellicle; (*c*) conidiophores most abundant on newest growth and disappearing with formation of pellicle, consisting of erect, swollen hyphae, with contents staining deeply in phloxine, frequently branched, septate, and slightly constricted at the septa, up to 15.0μ diameter, each bearing from 1 to 20 or more sterigmata up to 6.0μ long, in groups or solitary, at ends or along sides of conidiophores; (*d*) conidia hyaline, globose, echinulate, apiculate, containing one or more oil globules, 6.0–7.5μ diameter. *Submerged mycelium:* (*a*) hyphae as in advancing zone, up to 7.5μ diameter; (*b*) chlamydospores thin-walled, frequently vacuolate, ovoid, 12.0–16.5 × 7.5–12.0μ.

TYPE OF ROT: white butt rot of coniferous and broad-leaved trees, especially *Quercus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67).

The echinulate, globose spores produced by cultures of *Polyporus Berkeleyi* were interpreted as basidiospores by Davidson, Campbell, and Vaughn (67), and by Overholts (Letter, April 17, 1946). This view is supported by the appearance of the spores, which are identical with basidiospores. However, in the preceding description they have been considered as conidia because of their place of production at the margin of the growing colony, because the structures on which they are borne are too irregular to be considered as basidia, and because they are not shot off to form spore deposits when the Petri dishes are inverted. To ensure the recognition of cultures of the species both interpretations have been included in the key. The four key patterns so produced do not coincide with the key patterns for any other species, so that cultures of *P. Berkeleyi* should be readily identifiable.

Polyporus betulinus Bull. ex Fries

KEY PATTERN: 1 1 2 1 9 2 2 2 (1,2) (1,2) 2

CULTURES EXAMINED:

CANADA.—Quebec: Farm Point, on stump, F965; Gaspé County, on *Betula* sp., F945; Merrifield's Corners, on *B. lutea*, F1555. Ontario: Ingolf, on *Betula* sp., 9339; Petawawa, on *B. papyrifera*, 9338. British Columbia: Aleza Lake, on *Betula* sp., 16656.

CULTURAL CHARACTERS: (Pl. VII, Fig. 14; Pl. VIII, Figs. 41 to 43).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to four weeks. Advancing zone even, composed of well separated, curving, submerged hyphae, limit of growth visible only by transmitted light. Mat colorless to white, slightly raised, cottony to floccose, so thin as to be translucent, becoming collapsed after two to three weeks, with scattered 'dots' of more compact mycelium and, in some isolates, small compact balls usually grown against side wall of Petri dish, bearing fruiting surface. Reverse unchanged. Distinct odor of apples. On gallic and tannic acid agars no diffusion zones, colony 3.0–4.5 cm. diameter on gallic acid agar, 1.7–3.5 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 1.5–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, up to 9.0μ diameter, the broader ones frequently having irregularly thickened and refractive walls and lumina empty, the narrower ones with swellings that suggest chlamydospores but which remain thin-walled and eventually become empty and collapsed; (*b*) fiber hyphae rare except in fruit bodies, with walls thick and refractive, lumina narrow or apparently lacking, rarely branched, aseptate, 1.5–3.0μ diameter. *Fruit body:* (*a*) nodose-septate hyphae and (*b*) fiber hyphae as described above; (*c*) basidia 3.5–4.5μ diameter, bearing four spores; (*d*) basidiospores hyaline, even, allantoid, 4.5 $\times$ 1.5μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, octahedral.

TYPE OF ROT: brown cubical rot of sapwood of *Betula* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (55, 56), Davidson, Campbell, and Blaisdell (64), Macdonald (101).

To separate cultures of *Polyporus betulinus* from other species having the same key pattern, reference must be made to the descriptions of the species involved. None of them have noteworthy characters of diagnostic value but it is hoped that the complex of characters making up each species will be sufficiently distinct to allow for identification. In the case of *P. betulinus* host specificity may be helpful.

Polyporus borealis Fries

KEY PATTERN: 2 1 1 1 (0,1) 1 2 2 (2,3) 1 2

CULTURES EXAMINED:

CANADA.—New Brunswick: St. Andrew's, on *Picea* sp., F3581. British Columbia: Queen Charlotte Islands, on *Picea sitchensis*, 16070, 16071. Locality and host not known, F582. ALASKA.—On *P. sitchensis*, 11685, 11793. GERMANY.—Dresden, F1318.

CULTURAL CHARACTERS: (Pl. VII, Fig. 15; Pl. VIII, Figs. 44 to 48).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to six weeks. Advancing zone even, scant aerial mycelium to limit of growth. Mat white, at first farinaceous, then felty to pellicular (three to four weeks) with more or less conspicuous lines of slightly raised compact mycelium radiating from inoculum, forming foliose or large-pored fruit bodies over raised lumps at edge of Petri dish after four to six weeks. Reverse unchanged. Odor none. On gallic and tannic acid agars diffusion zones weak to strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, up to 6.0μ diameter; (*b*) contorted hyphal tips, numerous, irregularly branched, heavily incrusted, 4.5–6.0μ diameter; (*c*) chlamydospores numerous, thick-walled, intercalary and terminal, 12.0–21.0 $\times$ 6.0–16.5μ. *Fruit body:* (*a*) basidia 4.5–7.0μ diameter, bearing four spores; (*b*) cystidia fairly numerous, ventricose, 22.0–34.0 $\times$ 6.0–7.5μ; (*c*) basidiospores hyaline, even, ovoid, 4.5–7.0 $\times$ 3.5–4.5μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone, up to 7.5μ diameter; (*b*) chlamydospores as in aerial mycelium.

TYPE OF ROT: white mottled rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright and Findlay (56), Davidson, Campbell, and Blaisdell (64), Fritz (74), Robak (132).

Cultures of *Polyporus borealis* are distinctive, with characteristic incrusted contorted hyphal tips and coarsely pored fruiting bodies, which show typical cystidia in the hymenium. Each of the four key patterns, two listing each of these "special structures", stands alone in the key.

Polyporus brumalis Pers. ex Fries

KEY PATTERN: 1 2 1 1 6 (1,2) 2 2 (1,2) 2 (2,3)

CULTURES EXAMINED:

CANADA.—Quebec: Merrifield's Corners, on *Betula lutea*, F1554; Mt. Burnet, on *Ulmus* sp., 9434; Old Chelsea, F1608.

CULTURAL CHARACTERS: (Pl. IX, Fig. 1; Pl. VIII, Figs. 49 and 50).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone even, hyaline and appressed in zone 1.0–2.0 mm. wide. Mat white with scattered areas of "light vinaceous-cinnamon" (6.0YR6.8/4.3), "vinaceous-cinnamon" (6.5YR6.8/5.5), "cinnamon-buff" (9.0YR6.6/5.8), "tawny-olive" (8.0YR4.8/5.8), and "sayal brown" (7.0YR5.0/5.5) (two weeks), these increasing in extent and coalescing until whole surface is colored and mottled, or only isolated islands of white remain, the white areas appressed cottony to raised woolly, occasionally sectored, the colored areas skinlike and wrinkled. Reverse unchanged or bleached. Odor faint. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, diameter 2.0–2.5 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–4.5μ diameter. *Aerial mycelium*: (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, with walls thick and refractive, lumina narrow or apparently lacking, aseptate, branched, 1.5–3.0μ diameter; (*c*) hyphae from skinlike areas nodose-septate, with numerous branches, repeatedly branched or with small knoblike projections, so compactly arranged that it is almost impossible to prepare mounts showing individual elements. *Submerged mycelium:* (*a*) hyphae as in advancing zone, frequently branched; (*b*) chlamydospores found only in F1554, rare, terminal and intercalary, thin-walled, 9.0–13.5 × 6.0–9.0μ.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

As has been stated under *Polyporus arcularius*, no satisfactory basis for separating that species from *P. brumalis* has been arrived at in the present study, although the vinaceous tones of the former, and the clearer brown color of the latter species may be sufficiently constant to be of diagnostic value. One of the key patterns of *P. brumalis* coincides with those for *Collybia radicata* and *Daedalea confragosa*, but the colors of the mats of these, as noted in the descriptive key, are so different from those shown by *Polyporus brumalis*, as to permit separation.

Polyporus cinnabarinus Jacq. ex Fries

KEY PATTERN: (1,2) 2 1 1 9 1 2 2 2 1 2

CULTURES EXAMINED:

CANADA.—Quebec: Blue Sea Lake, on dead wood, F1377; Old Chelsea, F1609. Ontario: Ottawa, on *Betula lutea*, F1314. UNITED STATES.—Locality and host not known, F2176.

CULTURAL CHARACTERS: (Pl. IX, Fig. 2; Pl. X, Figs. 1 to 5).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, hyaline and appressed. Mat white at first, becoming "pinkish cinnamon" (6.0YR6.5/5.5) to "light ochraceous-salmon" (6.0YR 7.2/3.5) (two to six weeks) in more or less extensive areas, with granules and pored areas "zinc orange" (4.0YR5.5/7.0) to "flame scarlet" (2.0YR5.5/10.0) in color (three to six weeks), at first appressed and powdery, then with raised cottony areas, white or colored, over which the brightly colored granules form and coalesce to produce pored fruiting areas (three to four weeks). Reverse unchanged. Odor of green apples in young cultures. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, trace to 2.0 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently distorted, with numerous swellings; (*b*) fiber hyphae numerous, with walls thick and refractive, lumina narrow or apparently lacking, 2.0–3.0μ diameter, curving and interwoven; (*c*) chlamydospores numerous in older cultures, terminal or intercalary, with walls slightly thickened, 6.0–13.5 × 4.5–9.0μ. *Fruit body:* (*a*) basidia 4.5–6.0μ diameter, bearing four spores; (*b*) basidiospores hyaline, even, short cylindric, 4.5–6.0 × 2.2–3.0μ. *Submerged mycelium:* (*a*) nodose-septate and (*b*) fiber hyphae, and (*c*) chlamydospores as described above.

TYPE OF ROT: white rot of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

The vivid "zinc orange" and "flame scarlet" colors in cultures of *Polyporus cinnabarinus*, similar to the colors of the fruit body, make it possible to recognize the species easily, without recourse to microscopic examination and the use of the key.

Polyporus circinatus Fries

KEY PATTERN: 2 2 1 2 (2,7) (1,2) 2 2 4 2 1

CULTURES EXAMINED:

CANADA.—Quebec: Champlain County, on *Picea mariana*, 10270, 10271, 10272; Merrifield's Corners, on *Picea* sp., F1557; Notakim Depot, on *P. mariana*, 9416; Chelsea, on *Picea* sp., F987. Ontario: Timagami, 9825. UNITED STATES.—Locality and host not known, F2953.

CULTURAL CHARACTERS: (Pl. IX, Fig. 3; Pl. X, Figs. 6 to 10).

GROWTH CHARACTERS.—Growth very slow, radius 4.6–7.5 cm. in six weeks. Advancing zone usually even, in some isolates with fans of more rapidly growing mycelium extending beyond margin after four to five weeks, hyaline and appressed in zone 0.2–1.0 cm. broad. Mat "chamois" (2.0Y7.5/5.8), "honey yellow" (2.0Y6.7/6.2), "yellow ocher" (10.0YR 6.8/9.0), "buckthorn brown" (8.0YR4.8/6.5), "Sudan brown" (5.5YR3.8/5.5), and "argus brown" (5.5YR3.3/5.0), appressed, downy to thin velvety, usually not continuous over surface, but aerial mycelium lacking in some areas, the dark brown agar being exposed, frequently with small compact lumps near inoculum or elsewhere, which suggest fruit body fundaments. Reverse "tawny-olive" (8.0YR4.8/5.8), "Dresden brown" (9.0YR3.6/4.0), "Prout's brown" (5.5YR2.8/3.2), "bister" (4.5YR3.0/3.0), the darker colors frequently in irregular zones or patches. Odor none. On gallic and tannic acid agars diffusion zones moderately strong to strong, no growth or only a trace on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae hyaline to pale yellow or dark brown, with simple septa, branched, 1.5–4.5(–9.0)μ diameter; (*b*) globose swellings on hyphae frequent, terminal or intercalary, thin-walled, at first hyaline, with contents staining in phloxine, then brown, up to 15.0μ diameter; (*c*) chlamydosporelike bodies fairly numerous in cultures three weeks or more old, hyaline to golden brown, with walls slightly thickened and contents granular or oily in appearance, yellow or brown, usually plasmolyzed to an irregular mass, 7.5–21.0 × 4.5–9.0μ; (*d*) setae rare or apparently lacking in some isolates, dark brown, sharp pointed, 52.0–60.0 × 7.5–9.0μ. *Submerged mycelium:* (*a*) hyphae as described above, becoming paler with increasing depth in agar; (*b*) crystals octahedral.

TYPE OF ROT: white pocket rot of living coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright and Findlay (56), Christensen (58), Davidson, Campbell, and Blaisdell (64), Hubert (91).

According to Haddow (80) the proper name for the fungus here treated under *Polyporus circinatus* is *P. tomentosus* Fries. The mechanical difficulty of changing plates of drawings has made it expedient to treat it as originally planned under *P. circinatus*, even while accepting Haddow's argument for the use of the name *P. tomentosus*.

Setae were observed in only one isolate, 10270, which was obtained from a rot and identified as *P. circinatus* on the basis of cultural characters. Since setae were not found in the other cultures examined, some doubt is cast on the accuracy of the identification of this culture, and the question is raised as to whether setae occur in cultures of the species. Structures described as "chlamydosporelike bodies" are numerous and, since they may be interpreted as true chlamydospores, chlamydospores are included in the key patterns for the species. The key patterns without chlamydospores and with swellings or setae fall with *Fomes Pini* together with *Trametes tenuis* or *Poria ferruginosa*. The difficulty of separating cultures of *Fomes Pini* and *Polyporus circinatus* has been noted by Christensen (58) and Hubert (91), who based separation on the "faster growth and more abundant aerial mycelium" of *Fomes Pini* cultures. These macroscopic differences, along with the characteristic chlamydosporelike bodies in *Polyporus circinatus* and the brown thick-walled hyphae with expansions occurring singly or in series in *Fomes Pini*, should provide adequate criteria for the separation of these species.

Polyporus compactus Overholts

KEY PATTERN: 1 1 1 1 9 1 2 2 (1,2) 1 2

CULTURES EXAMINED:

CANADA.—Ontario: Constance Bay, on *Quercus rubra*, F7526; Petawawa, on *Q. rubra*, F7525; Port Credit, on *Q. alba*, F637, F7318. UNITED STATES.—Maryland: on *Q. alba*, F8004. Pennsylvania: on *Fagus grandifolia*, F8003.

CULTURAL CHARACTERS: (Pl. IX, Fig. 4; Pl. X, Figs. 11 to 15).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone even, hyaline and appressed in narrow zone. Mat white or with tinges of "massicot yellow" (7.0Y8.1/4.2), coarse cottony and tufted in newer growth, becoming appressed and firm felty to chamoislike in central zone (two weeks), this subsequently overgrown with tufts of mycelium bearing drops of yellow exudate, fruiting after two to three weeks, rarely in pored areas or zones, more commonly heavy spore deposits produced from whole tufted surface. Reverse unchanged. Odor faint in some isolates, strong in others, somewhat fruity. On gallic and tannic acid agars diffusion zones moderately strong to strong, colonies 2.0–4.0 cm. diameter on both media.

HYPHAL CHARACTERS.—*Advancing zone*: hyphae hyaline, nodose-septate, frequently branched, 2.2–4.5(–6.0)μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae with walls thick and refractive, lumina narrow or apparently lacking, aseptate, branched, 1.5–3.0μ diameter; (*c*) chlamydospores numerous, composing most of tufted and pored areas, with fairly thick walls, terminal or intercalary, 8.0–13.5 $\times$ 6.0–9.0μ. *Fruiting surface:* (*a*) basidia broad, 12.0–15.0 $\times$ 9.0–10.5μ, bearing four spores; (*b*) basidiospores hyaline, even, ovoid, truncate, 6.0–9.0 $\times$ 4.5–6.0μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone: (*b*) chlamydospores as in aerial mycelium, rare.

TYPE OF ROT: white rot of broad-leaved trees, usually *Quercus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67).

Polyporus compactus falls in the numerical key along with several other species, of which only *P. distortus* is so similar as to cause difficulty in separation. Both are characterized by the production of chlamydospores in great abundance, even the apparently well-organized pored areas consisting mainly of these bodies. Basidiospores differ in the two species, and the fact that *P. compactus* is usually on *Quercus* spp. is an additional valuable criterion in separating them.

Polyporus conchifer (Schw.) Fries

KEY PATTERN: 1 1 1 1 9 2 2 2 (1,2) 2 3

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, on *Ulmus* sp., F5033, 9343; Petawawa, on *Ulmus* sp., 10210.

CULTURAL CHARACTERS: (Pl. IX, Fig. 5; Pl. X, Figs. 16 and 17).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone even, at first hyaline and appressed, later with slightly raised woolly mycelium extending to limit of growth. Mat white, uniform, appressed, subfelty to floccose or somewhat tufted except in parts remote from inoculum where it is raised, woolly, grown against side of Petri dish. Reverse unchanged at first, then bleached. Odor none. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, trace to 2.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae with walls thick and refractive, lumina apparently lacking, 1.5–2.2μ diameter, with curving whiplashlike ends, closely interwoven to form tough mat. *Submerged mycelium:* (*a*) hyphae as in advancing zone, frequently branched; (*b*) crystals needlelike.

TYPE OF ROT: white rot of dead branches, usually of *Ulmus* spp., rarely of other broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

Polyporus conchifer has no distinctive cultural characters, and it is difficult to find any criteria by which this species may be differentiated from others with which it coincides in the numerical key. In the descriptive key, the textures of the mats of the different species have been used as a basis for separation. The subfelty to floccose mat of *P. conchifer* and the fact that it usually occurs on dead branches of *Ulmus* spp. may make possible the recognition of cultures of this species.

Polyporus cuticularis Bull. ex Fries

KEY PATTERN: 1 2 1 2 9 2 2 2 (2,3) (1,2) (1,2)

CULTURES EXAMINED:

CANADA.—Quebec: Farmer's Rapids, on *Acer* sp., F1969. Ontario: Lake of Bays district, on *Fagus grandifolia*, 10194; Timagami, on *Populus grandidentata*, F756. UNITED STATES.—Locality and host not known, F3052.

CULTURAL CHARACTERS: (Pl. IX, Fig. 6; Pl. X, Figs. 18 and 19).

GROWTH CHARACTERS.—Growth moderately rapid to very slow, plates covered in four to five (to seven) weeks, the rate of growth varying with the different isolates and with the same isolate at different times, being correlated with the type of growth. In faster growing cultures advancing zone even, with raised aerial mycelium extending to limit of growth; mat white (one to two weeks), to "colonial buff" (6.0Y8.5/5.5), "deep colonial buff" (4.0Y7.7/5.5), and "Isabella color" (1.0Y5.5/4.3) (two to three weeks), to "tawny-olive" (8.0YR4.8/5.8) in some isolates (three to six weeks), the newest growth raised, loosely arranged, cottony, later becoming appressed, woolly to subfelty, culture 10194 after six weeks developing raised lumps of paler mycelium, compactly arranged, surrounded by brown pored areas; reverse unchanged or "honey yellow" (2.0Y6.7/6.2) below newest growth. In slower growing cultures agar "snuff brown" (7.0YR3.9/3.5) to "bister" (4.5YR3.0/3.0) to edge of colony, advancing zone appressed; mat white (one to two weeks), to "straw yellow" (5.0Y9.0/5.5) and "old gold" (3.0Y5.8/5.5) (two to six weeks), cottony, so scanty as to allow dark color of agar to show through. This type of growth may constitute the entire colony or faster-growing, raised, cottony mycelium over pale agar may extend beyond in irregular areas or in a broad zone. No odor. On gallic and tannic acid agars diffusion zones very weak to moderately strong, no growth on gallic acid agar, trace to 2.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa (rare clamp connections in F1969), frequently branched, 1.5–6.0μ diameter. *Aerial mycelium*: hyphae as in advancing zone, with thin fragile walls, hyaline to pale brown. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white stringy rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright and Findlay (55, 56), Davidson, Campbell, and Blaisdell (64).

In preparing the key patterns for *Polyporus cuticularis* the faster growth rate has been correlated with lack of color in the reverse, and the slower growth rate with color in agar. This has reduced to four the number of times the species appears in the key. In all these places it falls along with several other species, and descriptive keys have been inserted. It should be mentioned that one culture (F1969) showed rare clamp connections in the advancing zone, and two (F1969 and 10194) had setae, although only one or two were found in mounts from each isolate. The occurrence of these structures appears to be too erratic to justify their inclusion in the descriptions or key.

Polyporus dichrous Fries

KEY PATTERN: (1,2) 1 2 1 9 2 2 2 (1,2) 2 2

CULTURES EXAMINED:

CANADA.—Ontario: Petawawa, 8287. British Columbia: Lumby, on *Pinus contorta* var. *latifolia*, 8118. UNITED STATES.—Locality and host not known, F3053.

CULTURAL CHARACTERS: (Pl. IX, Fig. 7; Pl. X, Fig. 20).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone even, hyaline and appressed, the coarse fibers separated so that limit of growth is difficult to see. Mat hyaline to white, completely submerged and appressed or with some areas developing scanty powdery to floccose or tufted mycelium after two to three weeks. Reverse unchanged or a characteristic greenish-yellow after two to three weeks. Odor strong, disagreeable. On gallic and tannic acid agars no diffusion zones, trace of growth on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.0μ diameter. *Surface* and *submerged mycelium:* hyphae as in advancing zone, usually 1.5–3.0μ diameter.

TYPE OF ROT: white rot of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

Except for the greenish-yellow color in the agar, and the strong disagreeable odor, cultures of *Polyporus dichrous* are notable only for their complete lack of distinctive characters. In the descriptive keys, *P. dichrous* is separated from other species having the same key patterns by absence of aerial mycelium, lack of fiber hyphae and chlamydospores, and no or only very restricted growth on gallic and tannic acid agars. However, these negative qualities provide satisfactory means of separation.

Polyporus distortus (Schw.) Fries

KEY PATTERN: 1 1 1 1 9 1 2 2 1 1 2

CULTURES EXAMINED:

UNITED STATES.—Mississippi: Locality and host not known, F8002. Locality and host not known, F7992.

CULTURAL CHARACTERS: (Pl. IX, Fig. 8; Pl. X, Figs. 21 to 25).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, hyaline and appressed for 2.0–3.0 mm. Mat white to "light pinkish cinnamon" (7.0YR 7.5/4.5), at first slightly raised, woolly-floccose, then appressed, woolly-felty, with scattered tufts and granules, these coalescing to form compact pored areas, characteristically with cup-like depressions surrounded by pores (three to four weeks). Reverse unchanged. No odor. On gallic and tannic acid agars diffusion zones strong, no growth or only a trace on gallic acid agar, diameter 1.5 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae fairly numerous, with walls thick and refractive, lumina lacking, rarely branched, aseptate, 1.0–2.2μ diameter; (*c*) chlamydospores very numerous even 2–3 mm. from limit of growth, terminal or rarely intercalary, with walls slightly thickened, 7.5–13.5 $\times$ 6.0–12.0μ; (*d*) clavate structures, with contents staining deeply in phloxine, observed only in F7992. *Fruit body:* (*a*) chlamydospores as described above make up most of mounts from pored areas; (*b*) basidiospores (from scant spore deposit) hyaline, even, broadly ovoid, apiculate, 5.4 $\times$ 3.6μ. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as described above; (*c*) crystals numerous, octahedral, minute.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

The similarity between cultures of *Polyporus distortus* and *P. compactus* has been mentioned in the remarks on the latter species. Differences in basidiospores and the usual occurrence of *P. compactus* on oak serve as distinguishing characters.

Polyporus dryadeus Pers. ex Fries

KEY PATTERN: (1,2) 2 1 2 9 2 2 2 4 2 1

CULTURES EXAMINED:

Locality and host not known, received from Centraalbureau voor Schimmelcultures, Baarn, 8101, 9238.

CULTURAL CHARACTERS: (Pl. IX, Fig. 9; Pl. X, Figs. 26 and 27).

GROWTH CHARACTERS.—Growth very slow, radius 5.0–6.0 cm. in six weeks. Advancing zone even, aerial mycelium uniform to limit of growth. Mat white in border about 0.5 cm. broad, then "yellow ocher" (10.0YR6.8/9.0) to "snuff brown" (7.0YR3.9/3.5) (two weeks), to "old gold" (3.0Y5.8/5.5), "Dresden brown" (9.0YR3.6/4.0), and "Sudan brown" (5.5YR3.8/5.5), in general the white and yellowish-brown areas downy to thin woolly-felty, the reddish-brown areas velvety. Reverse unchanged below newest growth, then "cinnamon-brown" (5.0YR3.0/3.0), "Brussels brown" (5.0YR3.5/4.0) to almost black below oldest part. No odor. On gallic and tannic acid agars diffusion zones moderately strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, frequently branched, with simple septa, 2.2–4.5μ diameter. *Aerial mycelium:* hyphae as in advancing zone but some with light brown walls, usually thin-walled and then appearing fragile and frequently distorted in mounts, occasionally with walls slightly thickened, frequently septate, 2.2–4.5μ diameter. *Submerged mycelium:* hyphae as in aerial mycelium.

TYPE OF ROT: white butt rot of broad-leaved trees, usually *Quercus* spp., and coniferous trees (reported on conifers only from Western United States).

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright and Findlay (51, 53, 56), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67).

It should be noted that the description of *Polyporus dryadeus* is based on the only two cultures available in the stock culture collection, both of which were received, in 1938 and 1939, from the Bureau voor Schimmelcultures, one accompanied by the information that it had been received from K. St. G. Cartwright of the Forest Products Research Laboratory at Princes Risborough, England. Neither of them has shown the friable or brittle texture or swollen cells described by Davidson, Campbell, and Vaughn (67) and Cartwright and Findlay (53) and so there is some doubt as to whether the cultures are still typical. In the key, *P. dryadeus* falls with several other brown, slow-growing species, but its preference for oaks as host, and the color range of the cultures may be sufficient to identify it.

Polyporus dryophilus Berk.

KEY PATTERN: 1 (1,2) 1 2 9 2 2 2 (2,3) 2 (1,3)

CULTURES EXAMINED:

UNITED STATES.—Locality and host not known, F2034, F2035, F2179.

CULTURAL CHARACTERS: (Pl. IX, Fig. 10; Pl. X, Figs. 28 to 30).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to five weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white (two weeks) to "colonial buff" (6.0Y8.5/5.5) and "chamois" (2.0Y7.5/5.8) (three weeks), and "honey yellow" (2.0Y6.7/6.2) (six weeks); outer zone raised to top of Petri dish, cottony to cottony-woolly, very loosely arranged, the color all in this mycelium; inner zone around inoculum somewhat collapsed, woolly, white or pale. Reverse below newer growth "honey yellow" (2.0Y6.7/6.2) to "bister" (4.5YR3.0/3.0), subsequently bleached, so that in cultures six weeks old agar below oldest part is bleached pure white, below newer growth is "auburn" (3.0YR3.0/4.0) to "bister" (4.5YR3.0/3.0) or nearly black. Odor none. On gallic and tannic acid agars diffusion zones strong, diameter 1.5–2.2 cm. on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 3.0–7.5μ diameter. *Aerial mycelium:* hyphae as in advancing zone, occasionally with walls yellow to brown. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, small, octahedral.

TYPE OF ROT: white pocket rot of broad-leaved trees, usually *Quercus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Bailey (4), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Long and Harsch (98).

The colors exhibited by cultures of *Polyporus dryophilus* may be pale, so it seems advisable to include it in both "colored" and "not colored" sections of the key. This possible variation in color, along with two growth rates and the color changes in agar, which necessitates listing under bleached and colored sections, results in *P. dryophilus* appearing in eight places in the key. The color and topography of its cultures are characteristic, and the succession of color changes in the agar, from light to dark brown and finally bleached, is unique, so that it should be possible to separate it readily from other species having identical key patterns.

Polyporus dryophilus var. **vulpinus** (Fries) Overholts

KEY PATTERN: 1 2 1 2 (6,9) 2 2 2 (2,3) (1,2) 2

CULTURES EXAMINED:

CANADA.—Ontario: Constance Bay, on *Populus tremuloides*, F4394; Timagami, on *Populus* sp., F830.

CULTURAL CHARACTERS: (Pl. IX, Fig. 11; Pl. X, Figs. 31 to 35).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to five weeks. Advancing zone even, raised cottony mycelium extending to limit of growth. Mat with broad white margin, changing gradually to "colonial buff" (6.0Y8.5/5.5) and "chamois" (2.0Y7.5/5.8) (three weeks) to "deep colonial buff" (4.0Y7.7/5.5), "honey yellow" (2.0Y 6.7/6.2), and "Isabella color" (1.0Y5.5/4.3) (four weeks), usually paler in older growth around inoculum, raised, cottony to cottony-plumose, collapsed around inoculum and becoming subfelty to skinlike, fruiting over inoculum after two weeks (F830), or later in organized, irregularly pored areas or over broad zones where basidia occur in scattered tufts. Reverse unchanged or slightly colored below inoculum, often with "Brussels brown" (5.0YR3.5/4.0) to "Argus brown" (5.5YR3.3/5.0) lines in agar. Odor none. On gallic and tannic acid agars diffusion zones moderately strong, colony 2.0 cm. diameter on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with rare, inconspicuous simple septa, branched, the branches frequently lying parallel to parent hyphae, 2.2–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, with septa more numerous, 1.5–4.5μ diameter; (*b*) in skinlike layer at surface of agar hyphae at first hyaline, the contents staining in phloxine, with numerous short curved branches, frequently with knoblike ends, finally with pale yellow walls, and apparently empty, firmly interlocked to form the homogeneous skin, so compact that component parts are no longer apparent. *Fruit body:* (*a*) basidia in tufts or in continuous hymenium, 6.0μ diameter, bearing four spores; (*b*) basidiospores brown, even, ovoid, 4.5–7.0 $\times$ 3.0–4.5μ, very abundant. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white pocket rot of *Populus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64) (under *Polyporus vulpinus*).

If the pseudoparenchymatous layer is observed and its characteristic cells listed under "special structures" in the numerical key, then *Polyporus dryophilus* var. *vulpinus* keys out alone or with *Hymenochaete tabacina* only, from which it is readily separated on the basis of color and texture. If the cultures do not show these specialized cells, then the key patterns may coincide with those of several other species, of which *Polyporus cuticularis* is particularly close to *P. dryophilus* var. *vulpinus*. The descriptive keys based on

color and topography must be consulted, and consideration must also be given to the fact that *P. dryophilus* var. *vulpinus* is specific to *Populus* spp.

Polyporus fibrillosus Karst.

KEY PATTERN: (1,2) 1 2 2 1 2 2 2 2 1 2

CULTURES EXAMINED:

CANADA.—Ontario: Petawawa, on *Abies balsamea*, 10909. British Columbia: Nitinat Trail, Vancouver Island, on *Picea sitchensis*, 8201; Queen Charlotte Islands, on *P. sitchensis*, 11708, 16075, on *Tsuga heterophylla*, 16042; Yellow Point, on log, 8238.

CULTURAL CHARACTERS: (Pl. IX, Fig. 12; Pl. X, Figs. 36 to 39).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, hyaline, appressed, limit of growth difficult to discern. Mat white, growth at first submerged, developing more or less extensive areas of appressed to slightly raised floccose to cottony mycelium after two to three weeks, this forming a fruiting surface consisting of granules and incomplete pores mixed with cottony mycelium, from which is produced a heavy spore deposit after five to six weeks. Reverse slightly deeper in color, "primuline yellow" (1.5YR7.5/9.5), "citron yellow" (7.0Y8.0/7.5), and "honey yellow" (2.0Y6.7/6.2), showing through the thin mat. Odor strong. On gallic and tannic acid agars no diffusion zones, diameter 2.0–4.0 cm. on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, frequently branched, with simple septa, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, up to 4.5μ diameter; (*b*) hyphae with greenish-yellow color, apparently aseptate, branched, 4.5–6.0μ diameter. *Fruiting surface:* (*a*) basidia in compact hymenium or loosely arranged clumps, frequently irregular in shape, about 6.0μ diameter, bearing four spores; (*b*) cystidia numerous, thin-walled, contents staining in phloxine, 3.0–4.5μ diameter, projecting up to 45μ; (*c*) basidiospores hyaline, even, cylindric-ellipsoid, 4.5–6.0 × 3.0μ. *Submerged mycelium:* (*a*) hyphae, hyaline and colored, as in aerial mycelium; (*b*) crystals large, octahedral.

TYPE OF ROT: brown rot of coniferous or, rarely, broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

The combination of characters shown by cultures of *Polyporus fibrillosus* is unique among the species studied, so that its key patterns are unlike any others in the key.

Polyporus fragilis Fries

KEY PATTERN: 2 1 2 1 9 2 2 2 4 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Gatineau Park, 10227; Mt. Burnet, on conifer, F6874.

CULTURAL CHARACTERS: (Pl. IX, Fig. 13; Pl. X, Figs. 40 and 41).

GROWTH CHARACTERS.—Growth very slow, radius 5.8–6.4 cm. in six weeks. Advancing zone even or slightly bayed, hyaline, appressed. Mat white, appressed, farinaceous to short woolly, so thin as to be translucent except in oldest part. Reverse unchanged. Odor slight at first, strong and bitter in six-weeks-old cultures. On gallic and tannic acid agars no diffusion zones, diameter 1.0 cm. on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–4.5μ diameter. *Aerial mycelium:* hyphae as in advancing zone, but frequently broken into segments one or two cells long, and occasionally with swellings. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals octahedral.

TYPE OF ROT: brown rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright and Findlay (56), Davidson, Campbell, and Blaisdell (64).

The key pattern for *Polyporus fragilis* coincides with that for *Trametes variiformis*, which shows a slow rate of growth and no fruiting. However, the numerous fiber hyphae of the latter species with the resultant felty to pellicular mat, make it decidedly different in appearance from the translucent growth produced by *Polyporus fragilis*.

Polyporus frondosus Dicks. ex Fries

KEY PATTERN: 1 1 1 1 9 1 2 2 (2,3) (1,2) (1,2)

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, 10235. UNITED STATES.—On *Quercus* sp., F2180. Locality and host not known, F2038.

CULTURAL CHARACTERS: (Pl. IX, Fig. 14; Pl. X, Figs. 42 to 46).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in three to six weeks. Advancing zone even, hyaline and appressed in band up to 0.5 cm. broad. Mat white or with tinge of "chamois" (2.0Y7.5/5.8) and "honey yellow" (2.0Y6.7/6.2) after two weeks, newest growth slightly raised, loosely arranged, woolly, soon becoming compact woolly-felty, thick and opaque, peeling readily from agar, in some isolates forming small pored fruit bodies after five to six weeks. Reverse unchanged or with some areas "tawny-olive" (8.0YR4.8/5.8) to "cinnamon-brown" (5.0YR3.0/3.0). Odor of carbide strong at two to five weeks, disappearing later. On gallic and tannic acid agars diffusion zones weak to strong, diameter trace to 2.5 cm. on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae fairly numerous or apparently lacking, with walls thick and refractive, lumina very narrow or lacking, branched, 1.5–3.0μ diameter; (*c*) chlamydospores few to abundant, with walls slightly thickened, terminal or intercalary, 10.5–22.0 $\times$ 9.0–16.5μ. *Fruit body:* (*a*) basidia 6.3–7.3μ diameter, bearing four spores; (*b*) basidiospores hyaline, even, apiculate, broadly ovoid, frequently with conspicuous oil drop, 4.5–6.3 $\times$ 3.6–4.5μ. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as described above; (*c*) crystals numerous, large, octahedral.

TYPE OF ROT: spongy butt rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright (50), Cartwright and Findlay (56), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67).

The coherent felty mat, which peels readily from the agar, and the conspicuously large chlamydospores, together with the characteristic odor of carbide, make cultures of *Polyporus frondosus* readily separable from other species having the same key patterns.

Polyporus fumosus Pers. ex Fries

KEY PATTERN: 1 1 (1,2) 1 9 1 2 2 2 (1,2) 2

CULTURES EXAMINED:

CANADA.—British Columbia: Saanichton, on English laurel, 10257. ENGLAND.—Cambridge, 9221.

CULTURAL CHARACTERS: (Pl. IX, Fig. 15; Pl. X, Figs. 47 to 51).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, with cottony fibers scattered over surface to limit of growth. Mat white, slightly raised, cottony, so loosely arranged as to be translucent, with scattered dots

or more or less extensive areas of opaque, subfelty mycelium, which may develop fruiting surfaces, waxy, minutely pored after three to four weeks, producing heavy spore deposits. Reverse unchanged. Odor fairly strong, suggesting turpentine. On gallic and tannic acid agars diffusion zones lacking or very weak, diameter 2.5–3.0 cm. on gallic acid agar, no growth or only a trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently broken up into short segments, occasionally with swelling up to 15.0μ diameter in older cultures; (*b*) chlamydospores numerous, intercalary or terminal, with walls somewhat thickened, broadly ovoid to elongate, 7.5–13.5 × 4.5–9.0μ. *Fruit body:* (*a*) basidia 3.6–5.4μ diameter, bearing four sterigmata and spores; (*b*) basidiospores hyaline, even, ellipsoid, or oblong, 3.6–4.5 × 2.7μ. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as in aerial mycelium; (*c*) crystals numerous, octahedral.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright (49), Cartwright and Findlay (56), Davidson, Campbell, and Blaisdell (64).

Since the key patterns for *Polyporus fumosus* include positive and negative reactions on gallic and tannic acid agars, and presence and absence of fruiting, the species occurs four times in the key, always in association with other species. Its cottony mat, translucent except for dots and larger areas that are subfelty to waxy and may become pored, and its very abundant chlamydospores, should be readily recognizable. Fruit bodies of *P. adustus* and *P. fumosus* are similar, but their cultures are readily separable, those of *P. fumosus* having a moderately rapid growth rate, numerous chlamydospores, and frequent fruiting, and those of *P. adustus* having a rapid growth rate, no chlamydospores but oidia, and no fruiting.

Polyporus galactinus Berk.

KEY PATTERN: 1 1 1 3 9 1 2 2 1 2 3

CULTURES EXAMINED:

CANADA.—Quebec: Mt. Burnet, on *Populus* sp., F3493, on *Ulmus* sp., F3494.

CULTURAL CHARACTERS: (Pl. XI, Fig. 1; Pl. X, Figs. 52 to 54).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, hyaline, appressed. Mat white, appressed, at first downy, having the appearance of a thin 'bloom' over surface of agar, after two to three weeks patchy, with some areas remaining downy, others becoming thin woolly, with farinaceous surface. Reverse unchanged for three to four weeks, then bleached. Odor faint or lacking. On gallic acid agar diffusion zone strong, no growth; on tannic acid agar diffusion zone weak to moderately strong, diameter up to 2.0 cm.

HYPHAL CHARACTERS.—*Advancing zone*: hyphae hyaline, at first thin-walled, the walls later becoming conspicuously thickened, branched, the branch constricted at point of emergence from parent hypha, with septa rare, simple, 4.5–6.0μ diameter, occasionally giving rise to nodose-septate branches. *Aerial mycelium:* (*a*) hyphae as in advancing zone rare but conspicuous in mounts, giving off nodose-septate branches; (*b*) hyphae hyaline, with thin walls, nodose-septate, branched, 1.5–3.0μ diameter; (*c*) chlamydospores very numerous even near margin, intercalary and terminal, with walls slightly thickened, globose to ovoid, 6.0–12.0μ diameter. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as in aerial mycelium.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

The broad, simple-septate hyphae of the advancing zone of *Polyporus galactinus* are striking in appearance and when first observed suggest a faster-growing

contaminant in advance of the nodose-septate hyphae that make up most of the mat. Similar types of hyphae are present in *P. resinosus* and *Poria albipellucida*. Cultures of *Polyporus galactinus* lack the strong fragrant odor of those of *P. resinosus*, and the growth of cultures of *P. galactinus* was inhibited completely on medium containing gallic acid, but good growth on this medium was found in *P. resinosus* and *Poria albipellucida*. These differences aid in the separation of these species.

Polyporus gilvus Schw. ex Fries

KEY PATTERN: (1,2) 2 1 2 (2,9) 2 2 2 2 (1,2) (1,2)

CULTURES EXAMINED:

UNITED STATES.—New Jersey: Hopewell, on *Acer* sp., F1965. Pennsylvania: State College, on *Quercus* sp., F1704.

CULTURAL CHARACTERS: (Pl. XI, Fig. 2; Pl. XII, Figs. 1 to 6).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white at first, slightly raised, short cottony, with the inoculum and some areas along radiating lines becoming "snuff brown" (7.0YR3.9/3.5), "Saccardo's umber" (9.0YR3.8/3.5), and "sepia" (7.0YR3.4/2.8), more compact, felty to velvety, in F1704 covered with minutely pored fruiting surface after three weeks. Reverse unchanged to "honey yellow" (2.0YR6.7/6.2) and "clay color" (10.0YR5.8/6.0) below colored mycelium. Odor lacking. On gallic and tannic acid agars diffusion zones strong, trace of growth on gallic acid agar, trace to 2.5 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, thin-walled, with simple septa, frequently branched, 2.2–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, in part with walls slightly thickened and yellow; (*b*) hyphae with thick, rigid, brown walls, branched, frequently occurring as isolated cells in otherwise hyaline hyphae, 3.0–6.0μ diameter; (*c*) hyaline, nodose-septate hyphae occasionally observed. *Fruit body:* (*a*) dark brown hyphae as in aerial mycelium; (*b*) setae numerous, 20.0-33.0 $\times$ 4.5–7.0μ; (*c*) basidiospores abundant, hyaline, even, oblong-ellipsoid, 4.0–5.0 $\times$ 2.0–2.5μ. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Hirt (84), Refshauge and Proctor (128).

In cultures of *Polyporus gilvus* the formation of setae is restricted to the fruiting surfaces. Therefore setae are included under "special structures" only in the key patterns in which fruiting is also listed, and the four key patterns showing this combination of characters fall alone in the key. Hence, when fruiting occurs, there should be little difficulty in identifying cultures of *P. gilvus*. The four key patterns that show no "special structures" and no fruiting are identical with the key patterns for several other species, among which separations must be based on color and texture, as noted in the descriptive keys. In some cultures rare nodose-septate hyphae were observed, but their formation seemed to be too erratic to warrant inclusion in the key.

Polyporus glomeratus Peck

KEY PATTERN: 1 2 1 2 (2,6,9) 2 2 2 4 2 1

CULTURES EXAMINED:

CANADA.—Quebec: Mt. Burnet, on *Acer rubrum*, F3491, on *Acer* sp., 11254.

CULTURAL CHARACTERS: (Pl. XI, Fig. 3; Pl. XII, Figs. 7 to 10).

GROWTH CHARACTERS.—Growth very slow, radius 3.0–7.5 cm. in six weeks. Advancing zone even, variable, with slightly raised aerial mycelium extending to limit of growth, or appressed and hyaline in broad zone, both types of margin sometimes appearing in different sectors of one colony. Mat frequently patchy, white to "barium yellow" (8.0Y8.0/6.5), "wax yellow" (4.0Y7.8/8.8), "yellow ocher" (10.0YR6.8/9.0), and "olive-yellow" (8.0Y 6.5/6.5), cottony to woolly, sometimes zonate, the aerial mycelium fairly plentiful in some areas, in others so thin that the color is masked by the dark brown color of the agar. Reverse colored to limit of growth in some colonies or sectors, "ochraceous-tawny" (6.0YR4.9/6.3), "cinnamon-brown" (5.0YR3.0/3.0), "mummy brown" (7.5YR2.5/2.3), to almost black. No odor. On gallic and tannic acid agars diffusion zones moderately strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) hyphae with walls yellowish-green to pale brown, contents concolorous or dark brown and granular, septate, 2.2–4.5μ diameter; (*c*) in skinlike areas hyphae with numerous short, curved branches, frequently with knoblike ends, with walls pale brown, firmly interlocked to form a pseudoparenchymatous layer; (*d*) setal hyphae fairly numerous or apparently lacking, dark brown, pointed, 4.5–9.0μ diameter, up to 300μ long. *Submerged mycelium:* hyphae with yellowish-brown walls and contents, frequently septate, 2.2–4.5μ diameter.

TYPE OF ROT: white rot and cankers of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell and Davidson (45), Davidson, Campbell, and Blaisdell (64).

If setal hyphae or the special cells comprising the pseudoparenchymatous layer are observed and included in the key patterns, then cultures of *Polyporus glomeratus* key out alone or with two other species having setae distinguishable from the setal hyphae of *P. glomeratus*. However, the species is variable, and cultures may be encountered that show neither of these "special structures". To meet this possibility a key pattern listing no "special structures" has been included for the species. This falls with a large group of species that have been treated in an inserted descriptive key.

Polyporus graveolens Schw. ex Fries

KEY PATTERN: 1 (1,2) 1 1 5 2 2 1 2 2 (1,2)

CULTURES EXAMINED:

UNITED STATES.—New York: Ithaca, F1604. Locality and host not known, F2954.

CULTURAL CHARACTERS: (Pl. XI, Fig. 4; Pl. XII, Figs. 11 to 14).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, hyaline and appressed. Mat white at first and remaining so (F1604) or changing abruptly after two to three weeks to "sayal brown" (7.0YR5.0/5.5) and "cinnamon-brown" (5.0YR3.0/3.0) around inoculum, the colored areas increasing in extent with age, appressed, cottony to subfelty to firm felty. Reverse unchanged for three to four weeks, then with some areas "buckthorn brown" (8.0YR4.8/6.5) to "cinnamon-brown" (5.0YR 3.0/3.0). Odor of pepper (F1604) or musty (F2954). On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, trace to 1.2 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, occasionally pale yellow; (*b*) fiber hyphae with walls slightly thickened but lumina remaining relatively broad, hyaline to greenish-yellow, branched, apparently aseptate, 1.0–3.0μ diameter, curving and interwoven; (*c*) oidia formed by the fragmentation of broader nodose-septate hyphae, frequently with clamp connection attached, 3.0–4.5μ diameter and of varying lengths; (*d*) cuticular cells thin-walled, collapsed and irregular, hyaline to pale brown, compactly arranged and mixed with fiber hyphae to form a pseudoparenchymatous layer. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67).

Cultures of *Polyporus graveolens* are unique among those treated in the present study in having a pseudoparenchymatous layer composed of cuticular cells, together with oidia. Davidson, Campbell, and Vaughn (67) describe structures resembling setal hyphae and chlamydospores, neither of which were recognized in the two cultures of the species available to the author for examination, and they omit mention of oidia and cuticular cells. This disagreement may be because of differences in interpretation of the structures observed or it may be due to the fact that the cultures used in the present study, being old, are no longer typical. As described above cultures of *P. graveolens* are similar to those of the species of *Ganoderma* studied in the structure of the pseudoparenchymatous layer and general appearance but differ from them in having oidia.

Polyporus guttulatus Peck

KEY PATTERN: (1,2) 2 2 1 9 2 1 2 2 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Maniwaki, 9418; Old Chelsea, on *Tsuga canadensis*, 11603. Ontario: Timagami, on *Abies balsamea*, F638; locality and host not known, F7331. British Columbia: Oyster River, on *Picea sitchensis*, 9337.

CULTURAL CHARACTERS: (Pl. XI, Fig. 5; Pl. XII, Figs. 15 to 17).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in four weeks. Advancing zone even, hyaline, appressed, so that limit of growth is difficult to see. Mat white in newest growth, changing through "vinaceous-buff" (7.0YR7.0/3.5) to "avellaneous" (8.0YR6.2/3.5) and "wood brown" (7.0YR5.7/4.0) (two weeks), to "tawny-olive" (8.0YR 4.8/5.8) and "Saccardo's umber" (9.0YR3.8/3.5) (six weeks), appressed downy to slightly raised cottony-floccose, with drops of amber exudate over surface, older cultures appearing more compact, felty, the surface somewhat reticulate, with farinaceous overgrowth. Reverse unchanged. Odor faint. On gallic and tannic acid agars no diffusion zones, diameter 2.0–3.5 cm. on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) conidiophores consisting of nodose-septate hyphae, of which the contents of the short terminal cell round up to form a conidium, the clamp connection at its base proliferating to produce a second short terminal cell and conidium, this process continuing until a small terminal head of conidia is produced; (*c*) conidia numerous, with walls slightly thickened, pale greenish-yellow in potassium hydroxide, contents staining deeply in phloxine, with conspicuous nonstaining granules, broadly ovoid, frequently with basal end flattened, 4.5–7.2 × 2.7–4.5μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, octahedral.

TYPE OF ROT: brown rot of coniferous or, rarely, broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

The conidia of *Polyporus guttulatus* and their method of formation are so characteristic that there should be no difficulty in recognizing cultures of the species. The only other species in the key in which spores are produced in a comparable manner is *Pholiota adiposa*, but there is no other similarity between the cultures of the two species.

Polyporus hirsutus Wulf. ex Fries

KEY PATTERN: (1,2) 1 1 1 9 (1,2) 2 2 (1,2) (1,2) 2

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, F1312; Petawawa, on *Crataegus* sp., 10217. British Columbia: Cowichan Lake, on *Alnus* sp., 9884; Oliver district, on *Prunus Armeniaca*, 10240; Vancouver, on *Alnus* sp., F2376. UNITED STATES.—New York: Phoenix, on *Ulmus americana*, F1304. SILESIA.—F1613. SIBERIA.—on *Betula verrucosa*, F1319.

CULTURAL CHARACTERS: (Pl. XI, Fig. 6; Pl. XII, Figs. 18 to 22).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone even, appressed in narrow zone or with slightly raised aerial mycelium extending to limit of growth. Mat white, at first raised, loosely arranged, cottony-floccose, becoming more compact, woolly to felty or almost plasterlike in older parts, sometimes reticulate, after two or three weeks with balls or large lumps over inoculum or elsewhere, frequently with waxy surface, covered with granules or more or less regular pores, or mycelium growing between Petri dish and cover to produce pored layer there. Reverse unchanged. No odor. On gallic acid agar diffusion zones very strong, no growth; on tannic acid agar diffusion zones moderately strong, diameter of colony 2.0–5.0 cm.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae very numerous, with walls thick and refractive, lumina narrow or apparently lacking, aseptate, branched, 1.5–3.0μ diameter. *Fruit body:* (*a*) basidia 4.5–6.3μ diameter, bearing four spores; (*b*) basidiospores hyaline, even, cylindric, 5.4–7.2 × 2.2–2.7μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores observed in one isolate, terminal and intercalary, thin-walled, 10.5–16.5 × 4.5–7.5μ.

TYPE OF ROT: white spongy rot of sapwood of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Bose (32, 33, 34), Davidson, Campbell, and Blaisdell (64), Humphrey and Siggers (92).

In spite of the possible variations recorded for *Polyporus hirsutus* in the present study it has been found most frequently without chlamydospores and with fruiting, and its common hosts are broad-leaved trees. With this combination of characters it keys out along with *Fomes roseus*, *Pleurotus ostreatus*, and *Schizophyllum commune*, the cultures of which are so distinctive macroscopically as to make possible easy separation. Other key patterns for *Polyporus hirsutus* coincide with those for *P. pubescens* and *P. zonatus*. So far no satisfactory means of separating these similar species has been found. In these and other groups with which *P. hirsutus* falls in the key, separations must be based on a combination of macroscopic and microscopic characters as given in the descriptive keys and in the descriptions.

Polyporus mollis Pers. ex Fries

KEY PATTERN: 2 (1,2) 2 2 9 2 2 2 2 2 (1,2)

CULTURES EXAMINED:

CANADA.—Quebec: Gaspé County, on *Abies balsamea*, F6816, on conifer, F6818, F6827. British Columbia: Cameron Lake, on *Pseudotsuga taxifolia*, 8411.

CULTURAL CHARACTERS: (Pl. XI, Fig. 7; Pl. XII, Figs. 23 and 24).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in four weeks. Advancing zone even or bayed, appressed, hyaline. Mat white but appearing colored by reason of color in surface layer of agar showing through thin aerial mycelium, "cream color" (3.0Y8.6/4.5), "avellaneous" (8.0YR6.2/3.5), and "wood brown" (7.0YR5.7/4.0) (one week), to "vinaceous-fawn" (4.5YR6.7/3.5) and "fawn color" (4.0YR5.6/4.2) (two weeks), to "pecan brown" (3.0YR4.7/4.5) (three weeks), the color at first limited to small area around inoculum, later extending over most of plate, the aerial mycelium appressed, downy to sparsely cottony, transparent. Reverse unchanged for two to three weeks, then with color of surface layer showing through. Odor none for two to three weeks, then unpleasant. On gallic and tannic acid agars no diffusion zones, colony 1.5–2.0 cm. diameter on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 3.0–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently branched, containing numerous oil globules or granules; (*b*) crystals numerous, variable in size, octahedral. *Submerged mycelium:* hyphae and crystals as in aerial mycelium.

TYPE OF ROT: brown rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3).

The appearance of color in cultures of *Polyporus mollis* is erratic, and for this reason the fungus is included in both the white and colored sections of the key, and in the sections showing color and not showing color in the agar. Two of the key patterns are unlike those for any other species treated in the present study, while two fall with those for *P. Schweinitzii*, in which the aerial mycelium is distinctly colored in contrast to *P. mollis*, in which the color is confined to the agar.

Polyporus montanus (Quél.) Ferry

KEY PATTERN: 2 1 1 2 9 (1,2) 2 2 3 2 2

CULTURES EXAMINED:

CANADA.—British Columbia: Oyster River, 8268; Queen Charlotte Islands, on *Tsuga heterophylla*, 11149, on ground, 11153; Saanichton, on *Abies grandis*, 8449.

CULTURAL CHARACTERS: (Pl. XI, Fig. 8; Pl. XII, Figs. 25 to 27).

GROWTH CHARACTERS.—Growth slow, plates covered in five to six weeks. Advancing zone even, appressed and hyaline in narrow zone. Mat white, at first appressed downy, then slightly raised, cottony to subfelty except for some areas or irregular zones in which mycelium is appressed and scanty, giving a somewhat zonate appearance. Reverse unchanged. Odor faint. On gallic and tannic acid agars diffusion zones weak to moderately strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 1.7–6.0μ diameter, usually about 3.0μ. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently containing numerous oil globules; (*b*) fiber hyphae with walls thick and refractive, lumina narrow or apparently lacking, occasionally branched, 1.5–3.0μ diameter; (*c*) chlamydospores rare or apparently lacking, with walls slightly thickened, terminal or intercalary, 9.0–13.5 × 7.5–10.5μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals large, octahedral.

TYPE OF ROT: white laminate rot of coniferous trees.

Polyporus montanus was described from Europe and records of its occurrence in North America appear to be rare. Lloyd (97) was of the opinion that it

did not occur on this continent, and that it is the "European analogue of *Polyporus Berkeleyi*" (Lloyd (96)). Dr. L. O. Overholts (Letter, April 17, 1946) stated that it had not been long known in North America but that he had "some fifteen collections from the west coast, including British Columbia . . . . . So far as I know it is confined to the west coast". The Department of Agriculture, Mycological Herbarium, Ottawa, contains six collections, all from western conifers, determined as *P. montanus* by Dr. Irene Mounce. Tissue cultures from five of these, and three additional cultures isolated from decays, have been examined. These are somewhat similar to cultures of *P. Berkeleyi*, but lack the echinulate conidia by which cultures of that species are readily recognized. This confirms the opinion that both *P. Berkeleyi* and *P. montanus* occur in North America, and provides additional evidence that *P. montanus* is confined to western conifers.

Cultures of *P. montanus* that have no chlamydospores have a key pattern identical with that for *Poria ferrea*, but since the latter always shows some colored areas its cultures are readily separated from those of the former species.

Polyporus obtusus Berk.

KEY PATTERN: 1 1 1 1 9 1 2 2 3 (1,2) 2

CULTURES EXAMINED:

CANADA.—Ontario: Petawawa, on *Quercus macrocarpa*, F6795; on *Q. rubra*, F6797, F6798, F6800.

CULTURAL CHARACTERS: (Pl. XI, Fig. 9; Pl. XII, Figs. 28 to 31).

GROWTH CHARACTERS.—Growth slow, plates covered in six weeks. Advancing zone even, raised woolly mycelium extending to limit of growth. Mat white, zonate, with zones of raised, woolly, opaque mycelium alternating with zones of appressed, cottony or felty, almost translucent mycelium, giving a 'waved' effect, forming small groups of waxy pores with fimbriate edges on F6798 after six weeks. Reverse unchanged. Odor strong ("Moderately fragrant. Jasmine" according to Badcock (3)). On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, colony 1.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, occasionally with numerous branches close together, producing witches' brooms; (*b*) fiber hyphae with walls thick and refractive, lumina apparently lacking except at tips, aseptate, not branched, 1.5–3.0μ diameter; (*c*) chlamydospores numerous, intercalary and terminal, thin-walled, 6.0–13.5 × 6.0–9.0μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores as in aerial mycelium; (*c*) crystals octahedral.

TYPE OF ROT: white rot of broad-leaved trees, usually *Quercus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67).

Both the key patterns listed above for *Polyporus obtusus* coincide with key patterns for *P. frondosus*, and one also coincides with that for *Poria asiatica*, but the zonate mat of *Polyporus obtusus* cultures, and the numerous chlamydospores that are noticeably smaller than those in *P. frondosus* and *Poria asiatica* should make separations possible.

Polyporus palustris Berk. and Curt.

KEY PATTERN: 2 1 2 1 9 1 2 2 2 1 2

CULTURES EXAMINED:

UNITED STATES.—Locality not known, on *Pinus Taeda*, F2045, on *Pinus* sp., 10618, 10620. Locality and host not known, F2964, F7641, F7642, 10250.

CULTURAL CHARACTERS: (Pl. XI, Fig. 10; Pl. XII, Figs. 32 to 36).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, downy white mycelium extending to limit of growth. Mat white, slightly raised, downy to cottony-floccose, becoming thin felty in the older parts of some isolates, after two to three weeks with scattered, small, raised balls of compact mycelium, these gradually increasing in size and frequently coalescing, with surface at first floccose, later compact and covered with more or less regular pores. Reverse unchanged. Odor faint. On gallic and tannic acid agars no diffusion zones, colonies 2.0–4.5 cm. diameter on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, rare in older cultures; (*b*) fiber hyphae with walls thick and refractive, lumina narrow or apparently lacking, aseptate, rarely branched, 1.5–3.0μ diameter, curving and interwoven; (*c*) chlamydospores rare, intercalary and terminal, thin-walled, 10.5–19.5 $\times$ 7.5–12.0μ. *Fruit body:* (*a*) nodose-septate and (*b*) fiber hyphae as in aerial mycelium; (*c*) basidia about 6.0μ diameter, bearing four spores; (*d*) basidiospores hyaline, even, cylindric, flattened on one side, apiculate, 6.0–9.0 $\times$ 2.0–3.0μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores as in aerial mycelium, fairly numerous; (*c*) broad hyphae with walls slightly thickened, nodose-septate but with clamp connections frequently distorted, contents staining deeply in phloxine, 7.5–9.0(–15.0)μ diameter, seen only in older cultures.

TYPE OF ROT: brown rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Nobles(117).

In the key *Polyporus palustris* falls with *Fomes subroseus*, *Polyporus balsameus*, *Poria monticola*, and *P. xantha*. Cultures of *Fomes subroseus* assume characteristic "shell pink" and "vinaceous pink" tones, and the chlamydospores of *Polyporus balsameus* become buffy-brown in color and impart this color to the mat so that cultures of these species are not to be confused with those of *P. palustris*, which remain white. Cultures of *Poria monticola* also remain white or pale but their early formation of foliose fruit bodies, their lack of fiber hyphae, and basidiospores 4.5–6.0 $\times$ 2.2–2.7μ differ from cultures of *Polyporus palustris*, where fruiting is in compact pored areas, fiber hyphae are numerous, and basidiospores are significantly longer, being 6.0–9.0 $\times$ 2.0–3.0μ. Like *Poria monticola*, *P. xantha* remains white, and lacks fiber hyphae, and its shorter basidiospores serve to distinguish it from *Polyporus palustris*. In addition, *P. palustris* is southern in its range, and will probably not be encountered in Northern United States or Canada.

Polyporus pargamenus Fries

KEY PATTERN: (1,2) 1 1 1 1 2 2 2 2 (1,2) 2

CULTURES EXAMINED:

CANADA.—Quebec: Chelsea, F5885. Ontario: Constance Bay, on *Populus* sp., F5216; Huntsville, on *Populus* sp., F2373; Timagami, on *P. tremuloides*, F1462. Alberta: Waterways, on *Betula neoalaskana*, F8016.

CULTURAL CHARACTERS: (Pl. XI, Fig. 11; Pl. XII, Figs. 37 to 41).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, downy aerial mycelium extending to limit of growth. Mat white, slightly raised, downy to floccose, with areas of raised cottony mycelium, small and scattered or extending over most of surface of some colonies; in F5885 mat thick, felty, papillate, the waxy surfaces of the papillae covered with basidia, which produce a heavy spore deposit in cultures four to five weeks old. Reverse unchanged. Odor none. On gallic and tannic acid agars diffusion zones weak to strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.7–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, with walls thick and refractive, lumina apparently lacking, aseptate, not branched, 2.5–4.0μ diameter, curving and interwoven; (*c*) cystidia formed of slightly enlarged hyphal tips each bearing a head of crystals. *Fruit body:* (*a*) thin-walled and (*b*) fiber hyphae as in aerial mycelium; (*c*) cystidia rare, walls somewhat thickened but lumina present and stained in phloxine, usually with cap of crystalline material, 4.5μ diameter, projecting up to 25.0μ; (*d*) basidiospores hyaline, even, cylindric, slightly curved, 5.0–6.5 $\times$ 2.2μ. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved or, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Macrae (103), Rhoads (130).

The difficulty of separating cultures of *Polyporus abietinus* and *P. pargamenus* has been discussed under the former species. As was implied there, cultures having the key pattern of these two species, and isolated from decay in broad-leaved trees are more likely to be *P. pargamenus* than *P. abietinus*.

Polyporus pubescens Schum. ex Fries

KEY PATTERN: 1 1 1 1 9 2 2 2 1 (1,2) (2,3)

CULTURES EXAMINED:

CANADA.—Quebec: Eardley, on *Alnus incana*, F7531. Ontario: Chalk River, on *A. incana*, 10214. UNITED STATES.—Pennsylvania: Lake Silkworth, on *A. incana*, F1652. Locality and host not known, F3058.

CULTURAL CHARACTERS: (Pl. XI, Fig. 12; Pl. XII, Figs. 42 and 43).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, with cottony, radiating mycelium extending to limit of growth. Mat white, newest growth cottony, then uniformly felty, more or less pitted, peeling from agar in coherent pellicle, in F7531 growing up side of Petri dish and there forming grayish, translucent, spongy masses without organized pores but producing spore deposits after five weeks. Reverse unchanged or bleached. No odor. On gallic and tannic acid agars diffusion zones moderately strong, no growth on gallic acid agar, colony 3.0–4.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–4.5(–7.5)μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, with walls thick and refractive, lumina narrow or apparently lacking, branched, the numerous branches usually at right angles to the main hypha, ending in whiplashlike ends, 1.5–3.0μ diameter. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, needlelike.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

In three of its four positions in the key *Polyporus pubescens* coincides with one or more other species having identical key patterns. In the inserted descriptive keys, attempts have been made to separate these on the basis of

distribution of fiber hyphae and topography of the mats, but no differences were observed whereby cultures of *P. pubescens* and *P. hirsutus* could be satisfactorily distinguished.

Polyporus radiatus Sow. ex Fries

KEY PATTERN: 1 2 1 2 (6,9) 2 2 2 2 2 1

CULTURES EXAMINED:

CANADA.—Quebec: Eardley, on *Alnus incana*, F7530; Old Chelsea, on *Acer spicatum*, 10229. Ontario: Ottawa, on *Pyrus* sp., F1565; Petawawa, on *Betula* sp., 10207. UNITED STATES.—New York: Jamesville, on *B. lutea*, F1966. Pennsylvania: Lake Silkworth, on *Betula* sp., F1650. Locality and host not known, received from Bureau voor Schimmelcultures, Baarn, F2286.

CULTURAL CHARACTERS: (Pl. XI, Fig. 13; Pl. XII, Figs. 44 to 46).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, slightly raised aerial mycelium extending to limit of growth. Mat with newest growth white, changing to "colonial buff" (6.0Y8.5/5.5) and "chamois" (2.0Y 7.5/5.8), slightly raised, cottony-woolly, somewhat tufted, the older part "olive-ocher" (3.0Y6.8/6.5), "honey yellow" (2.0Y6.7/6.2), and "Isabella color" (1.0Y5.5/4.3), appressed, short cottony, so sparse as to allow color of surface layers of agar to show through and obscure color of aerial mycelium. Reverse unchanged below newest growth, then "ochraceous-tawny" (6.0YR4.9/6.3), "cinnamon-brown" (5.0YR3.0/3.0), and "Prout's brown" (5.5YR2.8/3.2). Odor faint. On gallic and tannic acid agars diffusion zones weak to moderately strong, growth varying from a trace up to 2.0 cm. diameter on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, frequently branched, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, hyaline to pale brown, frequently septate, 2.2–3.0μ diameter; (*b*) hyphae dark brown, septate, 4.5–7.5μ diameter, giving off branches of type (*a*); (*c*) surface layers composed of hyphae with numerous short branches, frequently with knoblike ends, in some areas firmly interlocked to produce pseudoparenchymatous layer. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright and Findlay (55, 56), Davidson, Campbell, and Blaisdell (64), Humphrey and Siggers (92).

If the characteristic hyphae of the pseudoparenchymatous layer in cultures of *Polyporus radiatus* are observed and included, then the key pattern stands alone in the numerical key, and the culture should be readily determined. If these structures are not present, and the key pattern records no "special structures", then it falls in the key with a large group of colored species. Among these, separations must be made on the basis of color and texture, as set forth in the inserted descriptive key.

Polyporus resinosus Schrad. ex Fries

KEY PATTERN: (1,2) 1 1 3 (8,9) (1,2) 2 2 1 2 (2,3)

CULTURES EXAMINED:

CANADA.—Quebec: Chelsea, F1600; Eagle Depot, on *Pinus Banksiana*, 8549. Ontario: Ottawa, F2505, F2506; Peterborough, F2063. UNITED STATES.—New York: Fayetteville, on *Tilia americana*, F1301.

CULTURAL CHARACTERS: (Pl. XI, Fig. 14; Pl. XII, Figs. 47 to 50).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone slightly bayed, appressed, hyaline. Mat white, appressed, farinaceous to thin woolly and subfelty, with scattered dots or larger irregular areas in which mycelium is more or less raised, cottony-woolly. Reverse unchanged or bleached after five to six weeks. Odor very strong, sweet, of "equal parts benzaldehyde and anisealdehyde" (Badcock (3)). On gallic and tannic acid agars diffusion zones strong, trace to diameter of 2.0 cm. on gallic acid agar, colony 2.5–3.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, frequently branched, the branch constricted at point of emergence from parent hypha, with septa rare, inconspicuous, usually simple but occasionally with clamp connections, 3.0–7.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone limited to newest growth, giving rise to branches 1.5–3.9 (–4.5)μ diameter, regularly nodose-septate; (*b*) "lactiferous cells", conspicuous by reason of their large size and deeply staining contents, irregular in shape and size, up to 30.0μ diameter, numerous in some isolates, not observed in others. *Submerged mycelium:* (*a*) hyphae nodose-septate, frequently branched, 2.2–3.0μ diameter; (*b*) chlamydospores numerous in some isolates, apparently lacking in others, with walls slightly thickened, ovoid, 16.0–24.0 × 9.0–16.5μ.

TYPE OF ROT: white stringy rot of broad-leaved and coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (54), Davidson, Campbell, and Blaisdell (64), Snell, Hutchinson, and Newton (140).

With four characters that may vary, *Polyporus resinosus* has 16 key patterns. The broad, simple-septate hyphae, which give off nodose-septate branches, present in the advancing zone, are distinctive. This type of septation is present also in *Polyporus galactinus*, *Poria albipellucida*, and *P. cinerescens*, all of which have key patterns identical with some of those for *Polyporus resinosus*. The strong fragrant odor of cultures of *P. resinosus*, like that produced by its fruit body, and the conspicuous 'lactiferous cells' present in some isolates of the species, serve to distinguish it from the other species appearing in the key with it.

Polyporus rutilans Pers. ex Fries

KEY PATTERN: 1 2 1 1 9 2 1 2 2 (1,2) 2

CULTURES EXAMINED:

CANADA.—Ontario: Ingolf, 9311, 9312; Petawawa, on *Betula* sp., 11607.

CULTURAL CHARACTERS: (Pl. XI, Fig. 15; Pl. XII, Figs. 51 to 54).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in four weeks. Advancing zone even, white, aerial mycelium extending to limit of growth. Mat with narrow white border, then "deep colonial buff" (4.0Y7.7/5.5), "amber yellow" (4.0YR4.3/9.5), "chamois" (2.0Y7.5/5.8), and "honey yellow" (2.0Y6.7/6.2) (one week), to "old gold" (3.0Y5.8/5.5), (two weeks), "clay color" (10.0YR5.8/6.0), and "tawny-olive" (8.0YR4.8/5.8) where mycelium has grown up side of Petri dish (five weeks), turning purple when wet with potassium hydroxide solution, at first slightly raised, downy to thin woolly, then farinaceous, as if whole surface were sprinkled with coarse powder, in 11607 forming raised felty areas with pored surfaces after five weeks. Reverse unchanged. Odor strong at first, disappearing with age. On gallic acid agar diffusion zones strong, on tannic acid agar diffusion zones weak, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) conidiophores abundant, especially in young growth, formed from nodose-septate hyphae of which the terminal cells, 30.0–100.0μ long, bear closely crowded, short, pointed branches, each with a single, terminal conidium, the whole having a bottle-brush appearance; (*c*) conidia plentiful, hyaline, globose,

apiculate, 2.0–3.0μ diameter; (*d*) basidia with attached spores occur as ends of main hyphae or short terminal branches on aerial mycelium. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, large, octahedral.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3).

The conidiophores of *Polyporus rutilans* are so characteristic that there should be no difficulty in recognizing cultures of the species. However, the formation of conidiophores is restricted to a fairly narrow zone of new growth, and they may escape observation if no mounts are taken from this outer region. One other species, *Pholiota adiposa*, has the same key pattern as *Polyporus rutilans* but the methods of forming conidia in the two species are so different that they cannot be confused.

Polyporus Schweinitzii Fries

KEY PATTERN: 2 2 2 2 9 (1,2) 2 2 (1,2) 2 (1,2)

CULTURES EXAMINED:

CANADA.—Quebec: Chelsea, on *Pinus* sp., F7448; Gaspé County, on *Picea glauca*, F940. Ontario: Ottawa, on *Pinus mughus*, F1897; Timagami, on *P. resinosa*, F855, on *P. Strobus*, F728. British Columbia: Oyster River, on *Picea sitchensis*, 9420, on burned stump, 8270; Saanichton, on *Pseudotsuga taxifolia*, 8284; Vancouver, on *Thuja plicata*, F1039. JAPAN.—Kyoto: F1341.

CULTURAL CHARACTERS: (Pl. XIII, Fig. 1; Pl. XIV, Figs. 1 to 5).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to four weeks. Advancing zone even, hyaline and appressed in broad zone. Mat at first hyaline, submerged (one week), then with scattered tufts or small floccose areas "seafoam yellow" (9.0Y9.0/3.0), "chartreuse yellow" (9.0Y8.8/5.0), "primrose yellow" (7.0Y8.5/5.2), "deep colonial buff" (4.0Y7.7/5.5) (two weeks), later variable, with small, raised, soft cottony balls, "amber yellow" (4.0Y7.7/7.0), "primuline yellow" (1.5Y7.5/9.5), "honey yellow" (2.0Y6.7/6.2), or with more extensive velvety zones or irregular patches "raw sienna" (8.0YR5.3/8.5) to "antique brown" (8.0YR4.2/5.5) in color, with large areas of agar lacking aerial mycelium, hyaline to "buckthorn brown" (8.0YR4.8/6.5) and "amber brown" (4.0YR4.3/9.5), frequently with surface of mat appearing metallic or as if covered with shining particles to give a tinsel-like appearance. Reverse unchanged to "primuline yellow" (1.5Y7.5/9.5), "yellow ocher" (10.0YR6.8/9.0), and "buckthorn brown" (8.0YR 4.8/6.5). Odor pleasant, "almost anise" (Badcock (3)). On gallic and tannic acid agars no diffusion zones (agar may be reddish-brown below colonies), colony 3.0–5.5 cm. diameter on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 2.2–6.0μ diameter. *Aerial mycelium:* (color in mycelium dissolves in potassium hydroxide solution, turning it greenish-yellow) (*a*) hyphae as in advancing zone, up to 7.5–9.0μ diameter in some isolates; (*b*) hyphae with walls greenish-yellow and contents concolorous or dark brown in occasional cells, with simple septa, branched, the branches frequently lying parallel to parent hypha, 3.0–6.0μ diameter; (*c*) chlamydospores numerous in some isolates, rare or apparently lacking in others, concolorous with the hyphae in which they are formed, thick-walled, terminal or intercalary, globose to ovoid, 10.5–16.5μ diameter. *Submerged mycelium:* (*a*) hyphae as in advancing zone, up to 9.0μ diameter; (*b*) crystals octahedral.

TYPE OF ROT: brown cubical rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (51, 54, 56), Childs (57), Davidson, Campbell, and Blaisdell (64), Fritz (74), Humphrey and Siggers (92).

The variability of *Polyporus Schweinitzii* in culture has been recorded by Fritz (74), Childs (57), and others, and their observations have been corroborated in the present study. In preparing the description an attempt was made to include the range of characters found in cultures derived from the fruit bodies listed above. However, it should be noted that some isolates from decays grew more slowly, covering the plates only after five to six weeks, and some produced unmistakable diffusion zones on gallic and tannic acid agars, although most of these showed a negative reaction, more usual for the species, in subsequent tests. Since none of the authentic cultures from fruit bodies showed these variations they have been omitted from the description and key.

Boyce (35) and others have stated that *P. Schweinitzii* may occur on broad-leaved trees but such records are so rare that it has been included in the key only in the section on coniferous hosts.

In spite of its variability in culture, *P. Schweinitzii* is readily recognized, it being one of the few colored species showing a negative reaction on gallic and tannic acid agars. Its key patterns coincide only with those of *P. mollis*, in the cultures of which the color is confined to the surface layers of agar, while in cultures of *P. Schweinitzii* the aerial mycelium is definitely colored.

Polyporus semipileatus Peck

KEY PATTERN: (1,2) 1 1 1 0 2 2 2 4 2 (1,2)

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, F3499. Locality and host not known, F7335.

CULTURAL CHARACTERS: (Pl. XIII, Fig. 2; Pl. XIV, Figs. 6 and 7).

GROWTH CHARACTERS.—Growth very slow, radius 4.5 cm. or less in six weeks. Advancing zone even, submerged, making it difficult to see limit of growth. Mat white, appressed, farinaceous to thin felty, with scattered dots of more compact mycelium. Reverse unchanged to "cinnamon-brown" (5.0YR3.0/3.0) and "Prout's brown" (5.5YR2.8/3.2). No odor. On gallic and tannic acid agars diffusion zones moderately strong to strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.0–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, rare; (*b*) contorted incrusted hyphal tips, 4.5–6.0μ diameter over incrustation, form whole surface. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved or, rarely, coniferous trees.

The description of *Polyporus semipileatus* was based on the only two cultures available. They are similar and readily separated from other species in the key by reason of the abundant, incrusted, contorted hyphal tips, which make up most of the surface of the cultures, and the slow rate of growth.

Polyporus squamosus Huds. ex Fries

KEY PATTERN: 1 (1,2) 1 1 (6,9) 2 2 1 4 2 2

CULTURES EXAMINED:

CANADA.—Ontario: Antrim, on *Ulmus americana*, F2274; Ottawa, on *Ulmus* sp., F364, F3512, 10789.

CULTURAL CHARACTERS: (Pl. XIII, Fig. 3; Pl. XIV, Figs. 8 to 10).

GROWTH CHARACTERS.—Growth very slow, radius 8.5 cm. or less in six weeks. Advancing zone even, mat uniform to limit of growth. Mat white, with or without small areas "snuff brown" (7.0YR3.9/3.5) to "drab" (9.0YR5.5/2.0) around inoculum, appressed, fibers fine, short, straight, recumbent, producing a uniform surface except for occasional skinlike areas or zones in which superficial aerial mycelium is completely lacking. Reverse unchanged. Odor none. On gallic and tannic acid agars diffusion zones weak to moderately strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone*: hyphae nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) oidia very numerous, formed 2–3 mm. inside limit of growth, by the fragmentation of nodose-septate hyphae, with dense granular contents, variable in shape from narrow-elongate to broadly-ellipsoid, 3.0–6.0μ diameter, up to 45.0μ in length; (*c*) in skinlike layer at surface of older parts of colony, hyphae with walls slightly thickened and refractive, septate, with numerous nodules and irregular protuberances, compactly arranged to form a pseudoparenchymatous layer. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (55, 56), Davidson, Campbell, and Blaisdell (64), Vandendries (146).

If the characteristic cells of the pseudoparenchymatous layer are observed and listed in the key pattern, or if the color of the culture is sufficiently pronounced to warrant its inclusion in the section treating cultures with colored mats, then the key patterns for *Polyporus squamosus* fall alone in the key. A culture that remains white and shows no pseudoparenchymatous layer keys out with *P. umbellatus* and there appears to be no means of distinguishing between cultures of these two species.

Polyporus subcartilagineus Overholts

KEY PATTERN: (1,2) 1 2 1 9 2 2 2 3 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Notakim Depot, north of Maniwaki, on *Picea mariana*, 9417.

CULTURAL CHARACTERS: (Pl. XIII, Fig. 4; Pl. XIV, Fig. 11).

GROWTH CHARACTERS.—Growth slow, plates covered in five weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white, raised, cobwebby-cottony to plumose, becoming collapsed and appressed in central part, but remaining raised around edge of Petri dish. Reverse unchanged. No odor. On gallic and tannic acid agars no diffusion zones, colony 2.0 cm. diameter on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone, aerial mycelium,* and *submerged mycelium:* hyphae all uniform, hyaline, nodose-septate, 2.2–6.0μ diameter.

TYPE OF ROT: brown carbonizing rot of broad-leaved and coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson and Campbell (63).

The only culture of *Polyporus subcartilagineus* in the collection was isolated from the rot accompanying a fruit body on *Picea mariana*, collected in the same location as the type but in the following year. Since the species is a recently described one (Overholts (121)) it seems advisable to include a description of its cultural characters even though it is based on only one culture. Davidson and Campbell (63) described cultures of the species isolated from black cherry and their cultures appear similar to the one used in the present study although no chlamydospores were observed in the latter

isolate. In both appearances in the key *P. subcartilagineus* falls with several other species from which it may be separated by reason of its raised cottony to plumose initial growth and its lack of fiber hyphae.

Polyporus sulphureus Bull. ex Fries

KEY PATTERN: (1,2) 1 2 2 9 1 (1,2) 2 2 2 2

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, on *Quercus* sp., F1543. British Columbia: Queen Charlotte Islands, on *Picea sitchensis*, 11710, 11711. UNITED STATES.—Pennsylvania: on *Quercus* sp., F2183. Locality not known, on *Quercus* sp., F2046.

CULTURAL CHARACTERS: (Pl. XIII, Fig. 5; Pl. XIV, Figs. 12 to 15).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, appressed, with scattered tufts of mycelium over zone of newest growth, 1.0–2.0 cm. broad. Mat white to "pale ochraceous-buff" (8.5YR8.0/3.5) and "pale ochraceous-salmon" (9.0YR8.2/2.5), slightly raised, floccose-farinaceous. Reverse unchanged. Odor none. On gallic and tannic acid agars no diffusion zones, colonies 3.0–4.0 cm. diameter on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 3.0–9.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, usually 3.0–6.0μ diameter, the few broader hyphae conspicuous; (*b*) conidiophores numerous, making up most of aerial mycelium, 2.2–3.0μ diameter, branched in spraylike manner, bearing a single conidium at end of each branch; (*c*) conidia numerous, thin-walled, broadly ovoid to subglobose, 6.0–9.0 × 6.0–7.5μ; (*d*) chlamydospores fairly numerous, with walls slightly thickened, terminal and intercalary, 12.0–19.5 × 7.5–13.5μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores as in aerial mycelium.

TYPE OF ROT: brown cubical rot of broad-leaved and coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (51, 53, 54, 56), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Fritz (74), Humphrey and Siggers (92).

Fritz (74) and Davidson, Campbell, and Vaughn (67) considered all the secondary spores of *Polyporus sulphureus* to be chlamydospores, although they noted that those borne on the aerial mycelium are smaller than those produced on the submerged hyphae. On the other hand, Cartwright and Findlay (53) called the spores on the aerial mycelium conidia, and this interpretation has been followed in the above description, while the larger spores of the submerged mycelium have been considered as typical chlamydospores. However, to meet the possibility of the secondary spores all being taken as chlamydospores, key patterns for the species are included, which show only chlamydospores, and both chlamydospores and conidia. Each of the four resulting key patterns occurs alone in the key so there should be no difficulty in determining cultures of *P. sulphureus*.

Polyporus tuberaster Jacq. ex Fries

KEY PATTERN: (1,2) 2 1 1 (6,9) 2 2 2 (2,3) 2 1

CULTURES EXAMINED:

CANADA.—Manitoba: Raeburn, F2349. Alberta: Grande Prairie, F984. ITALY.—Avellino, F7997. Locality and host not known, received from Centraalbureau voor Schimmelcultures, Baarn, F6623.

CULTURAL CHARACTERS: (Pl. XIII, Fig. 6; Pl. XIV, Figs. 16 to 18).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to six weeks. Advancing zone even, aerial mycelium to limit of growth. Mat white at first, becoming "pinkish buff" (9.0YR7.3/4.5), "cinnamon-buff" (9.0YR6.6/5.8), "tawny-olive" (8.0YR4.8/5.8), "snuff brown" (7.0YR3.9/3.5), "avellaneous" (8.0YR6.2/3.5), and "buffy-brown" (9.0YR4.6/3.5), the color usually restricted to an area around the inoculum or to certain zones, appressed, downy to subfelty, then felty to pellicular or, in colored area around inoculum, with glazed surface almost lacking aerial mycelium. Reverse unchanged for one to two weeks, then with scattered lines or patches of "snuff brown" (7.0YR3.9/3.5) to "bister" (4.5YR3.0/3.0) below colored areas in mat. No odor. On gallic and tannic acid agars diffusion zones moderately strong to strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, frequently branched, thick-walled, lumina visible only at bases of branches, 1.5–3.0μ diameter; (*c*) in skinlike areas hyphae nodose-septate, with numerous short branches or irregular protuberances, having thick refractive walls, all closely interwoven with fiber hyphae to form a pseudoparenchymatous layer. *Submerged mycelium:* hyphae as in advancing zone.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Mounce (110).

Fruit bodies of *Polyporus tuberaster* grow from an underground sclerotium-like structure, which may enclose foreign material such as stones and portions of roots (Güssow (77)). There is no suggestion that the species can cause decay. It is included in the present study merely because of its academic interest and to record that isolates received from Europe appear to be identical with those isolated from sclerotia or the fruit bodies produced therefrom collected in Western Canada. Since there is no provision in the key for species of fungi that are not wood-inhabiting, *P. tuberaster* has been included with the species occurring on both broad-leaved and coniferous trees. Having two other variable characters it occurs eight times, and in two places coincides with the key patterns for *Daedalea confragosa*. The rarity and restricted known range for *Polyporus tuberaster* makes it extremely unlikely that this species will be encountered among cultures to be identified.

Polyporus Tulipiferae (Schw.) Overholts

KEY PATTERN: 1 1 (1,2) 2 9 2 2 2 (1,2) 2 3

CULTURES EXAMINED:

CANADA.—Ontario: Ottawa, on *Sorbus Aria*, F8048, on *Quercus* sp., F8049, on *Rosa* sp., F8047. British Columbia: Summerland, on *Prunus Armeniaca*, 10233. UNITED STATES.—Locality and host not known, F369, F2958.

CULTURAL CHARACTERS: (Pl. XIII, Fig. 7; Pl. XIV, Figs. 19 and 20).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone even, slightly raised aerial mycelium extending to limit of growth. Mat white, slightly raised, cottony to floccose-cottony, with aerial mycelium more abundant in some areas, raised, spongy-woolly, somewhat tufted. Reverse bleached. Odor strong, disagreeable but not identified, becoming less noticeable in cultures five to six weeks old. On gallic and tannic acid agars diffusion zones lacking or weak, colony 2.5–6.5 cm. diameter on gallic acid agar, no growth or colony up to 1.5 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 3.0–6.0μ diameter. *Aerial mycelium:* hyphae as in advancing zone, 1.5–6.0μ diameter, most frequently 1.5–3.0μ; (*b*) fiber hyphae numerous in some isolates, rare or apparently lacking in others, with walls thick and refractive but lumina visible, rarely septate, occasionally branched, 2.0–3.0μ diameter. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Darley and Christensen (61), Davidson, Campbell, and Blaisdell (64).

Three of the key patterns for *Polyporus Tulipiferae* occur alone in the key, while the fourth coincides with that for *P. dryophilus*. Cultures of *P. Tulipiferae* remain white, while those of *P. dryophilus* assume yellow or buff colors that may be pale but are distinct. Hence there should be no difficulty in separating cultures of the two species.

Polyporus umbellatus Pers. ex Fries

KEY PATTERN: 1 1 1 1 9 2 2 1 4 2 (1,2)

CULTURES EXAMINED:

CANADA.—Ontario: Petawawa, 9263. Locality and host not known, received from Centraalbureau voor Schimmelcultures, Baarn, F7336.

CULTURAL CHARACTERS: (Pl. XIII, Fig. 8; Pl. XIV, Figs. 21 and 22).

GROWTH CHARACTERS.—Growth very slow, radius 4.7 cm. or less in six weeks. Advancing zone slightly bayed, aerial mycelium uniform to limit of growth. Mat white, appressed, compact, velvety to coarse farinaceous, appearance suggesting rough plaster. Reverse unchanged or "honey yellow" (2.0Y6.7/6.2) to "cinnamon-brown" (5.0YR3.0/3.0) below inoculum. Odor faint. On gallic and tannic acid agars diffusion zones very weak to moderately strong, no growth on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, the cells short, with numerous branches originating at and between septa, 3.0–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, soon fragmented to form (*b*) oidia of diameter equal to hyphae and of varying lengths, frequently with clamp connection attached, 9.0–15.0 × 3.0–4.5μ. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

Polyporus umbellatus and *P. squamosus* fall together in the key and there appears to be no clearly defined character by which they may be separated.

Polyporus versicolor L. ex Fries

KEY PATTERN: (1,2) 1 1 1 9 (1,2) 2 2 (1,2) 2 3

CULTURES EXAMINED:

CANADA.—British Columbia: Saanichton, on *Arbutus Menziesii*, 8182, on *Juglans* sp., 8183; Summerland, on *Prunus* sp., 10019; Vancouver, on *Cornus Nuttallii*, 10021.

CULTURAL CHARACTERS: (Pl. XIII, Fig. 9; Pl. XIV, Figs. 23 to 25).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone even, hyaline, appressed for short distance in advance of aerial mycelium. Mat white with tinge of "cream color" (3.0Y8.6/4.5), raised cottony-woolly in newer growth and remaining so in some areas, otherwise felty, with drops of exudate that may leave the surface punctate on their disappearance, mycelium grown up sides of Petri dish and across cover after three weeks. Reverse bleached after three to four weeks. Odor strong, "fish and tallow" according to Badcock (3). On gallic and tannic acid agars diffusion zones moderately strong, trace of growth to colony 1.5 cm. diameter on gallic acid agar, colony 2.5–3.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 3.0–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber-hyphae numerous, thick-walled, lumina discernible only at bases of branches, frequently branched, 2.0–3.0μ diameter, curving and interwoven; (*c*) chlamydospores fairly numerous in some isolates, usually found lying free in preparations for microscopic examination, thin-walled, 4.5–7.5 × 2.2–4.5μ. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white spongy rot of broad-leaved and, rarely, coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Bayliss (27), Cartwright and Findlay (51, 52, 55, 56), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Fritz (74), Humphrey and Siggers (92), Jay (93), Refshauge and Proctor (128), Vandendries and Brodie (147, 148).

Six of the eight key patterns assigned to *Polyporus versicolor* fall with others in the key, in groups that are difficult to separate. The chlamydospores of *P. versicolor* are significantly smaller than those of other species in the groups, and this character, along with the distinctive, strong 'fishy' odor and the cottony-woolly to felty mat, which often becomes punctate, may permit recognition of cultures of this species.

Polyporus volvatus Peck

KEY PATTERN: 2 1 1 1 7 2 2 2 (2,3) 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Gaspé County, on *Picea glauca*, F6814, 10188. UNITED STATES.—Locality and host not known, F3060.

CULTURAL CHARACTERS: (Pl. XIII, Fig. 10; Pl. XIV, Figs. 26 to 28).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in three to six weeks. Advancing zone even, appressed so that it is difficult to see limit of growth. In F6814 and 10188 growth mostly submerged, sodden, translucent except for some opaque dots within or at the surface of the agar, where they may coalesce, especially in the vicinity of the inoculum, to form opaque areas with irregular 'bubbly' surface, in F3060 mat white, appressed, thin farinaceous. Reverse unchanged. Odor pungent. On gallic and tannic acid agars diffusion zones moderately strong, no growth on gallic acid agar, trace of growth to diameter of 1.0 cm. on tannic acid agar (Davidson, Campbell, and Blaisdell (64)).

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–4.5μ diameter. *Aerial* and *submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae (observed only in F3060) with walls thick and refractive, frequently branched, 1.5–2.2μ diameter; (*c*) hyphae with swellings, usually in moniliform arrangement, nodose-septate, the clamps being small and inconspicuous, with granular contents, very numerous, especially in opaque areas, 7.5–15.0μ diameter.

TYPE OF ROT: white rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Zeller (153).

The sodden appearance of the cultures and the minute granules floating in the mounting medium suggest the presence of a bacterial contaminant but since all the cultures, including some isolated from decays and not listed above, had this appearance, it has been accepted as typical for the species. The characteristic hyphae with swellings are of diagnostic value, being found only in this one species of all those included in the key. The "conidiospores" described by Zeller (153) were not observed in any of the cultures available.

Polyporus zonatus Fries

KEY PATTERN: 1 1 1 1 9 1 2 2 1 2 (2,3)

CULTURES EXAMINED:

NORWAY.—Oslo, on *Alnus incana*, F7388, on *Populus tremula*, F7389, on *Salix caprea*, F7390. Locality and host not known, received from Bureau voor Schimmelcultures, Baarn, F2280.

CULTURAL CHARACTERS: (Pl. XIII, Figs. 11, 12; Pl. XIV, Figs. 29 to 31).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, in some isolates appressed and hyaline so that it is difficult to see limit of growth, in others with the raised aerial mycelium extending to limit of growth. Mat white, the first growth slightly raised, woolly-floccose, becoming collapsed, farinaceous to thin woolly, later the whole surface appressed, felty to pellicular, sometimes appearing rough or pebbled. Reverse unchanged or bleached after two to three weeks. Odor none or slight. On gallic and tannic acid agars diffusion zones moderately strong to strong, no growth on gallic acid agar, colony 1.5–3.3 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5(–6.0)μ diameter. *Aerial mycelium:* (*a*) hyphae as in the advancing zone, the septa usually close together and the branches numerous, in some isolates with narrow staghorn branches; (*b*) fiber hyphae numerous, with walls thick and refractive and lumina apparently lacking, frequently branched, 1.5–3.0μ diameter; (*c*) chlamydospores fairly numerous to rare, terminal and intercalary, thin-walled, 6.0–12.0 × 4.5–7.5(–9.0)μ. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as described above; (*c*) crystals numerous, slender, needle-like.

TYPE OF ROT: white rot of broad-leaved trees.

The description of *Polyporus zonatus* is based on four cultures received from Europe, there being no isolates from American specimens in the stock culture collection. Its inclusion at least puts on record the cultural characters of *P. zonatus* as it is known in Europe, and may permit comparison of these cultures with American isolates of the species. *P. zonatus* coincides in the key with *P. versicolor*, and cultures of the two species appear so similar as to be indistinguishable.

Poria albipellucida Baxter

KEY PATTERN: (1,2) 1 1 3 9 1 2 (1,2) 1 2 (2,3)

CULTURES EXAMINED:

CANADA.—British Columbia: Cowichan Lake, on *Thuja plicata*, 9264, 9285, 11692; Newton, on *T. plicata*, 8246; Saanichton, on *Pseudotsuga taxifolia*, 9757; locality not known, on *Thuja plicata*, 11605; neither locality nor host known, 11268.

CULTURAL CHARACTERS: (Pl. XV, Fig. 1; Pl. XVI, Figs. 1 to 5).

GROWTH CHARACTERS.—Growth rapid, plates covered in one to two weeks. Advancing zone even, hyaline, appressed. Mat white, at first appressed or submerged, with aerial mycelium thin downy or almost lacking, translucent except for numerous scattered V-shaped areas, with points directed away from inoculum, opaque because of denser growth within agar and fine woolly to farinaceous surface, later with overgrowth of slightly raised woolly or cottony mycelium beginning around edge of Petri dish and growing inward, in some isolates covering most of surface, in others restricted to band around outside. Reverse unchanged or partially bleached, the V-shaped thickenings prominent. No odor. On gallic acid agar diffusion zone very strong, colony 5.0–8.0 cm. diameter; on tannic acid agar diffusion zone moderately strong, colony trace to 1.5 cm. diameter.

HYPHAL CHARACTERS.—*Advancing zone:* leading hyphae hyaline, thin-walled at first but walls soon becoming thickened, with rare, inconspicuous, simple septa, 3.0–7.5μ diameter, frequently branched, the branches soon developing clamp connections. *Aerial mycelium:* (*a*) thick-walled hyphae with simple septa as in advancing zone, rare but conspicuous; (*b*) nodose-septate hyphae, 1.5–3.0μ diameter; (*c*) chlamydospores usually numerous, terminal and intercalary, globose and subglobose, 7.5–10.5μ diameter; (*d*) oidia rare in some isolates, apparently lacking in others, formed in advancing zone by fragmentation of hyphae with simple septa, 4.5–6.0μ diameter, of varying lengths. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) rare chlamydospores as described above.

TYPE OF ROT: white laminate rot of coniferous and broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Buckland (38).

Morphological differences in the fruit bodies of *Poria albipellucida* and *P. cinerescens*, particularly in the basidiospores, which are ovate, 4.5–5.0 × 3.5–4.5μ in the former (Cooke (60)) and cylindric, 4.5–6.0 × 1.5–2.5μ in the latter (Overholts (122)) establish the existence of two species, but separation of the cultures on the basis of the diagnostic characters employed in the present study, has proved impossible. For this reason the two species have been listed together in the key, and no description or illustrations of *P. cinerescens* have been included, since they appear to be identical with those given for *P. albipellucida*. In the key *P. albipellucida* coincides with *Polyporus resinosus* in three places, with *P. galactinus* in one. The characteristic V-shaped thicker areas in the mat of *Poria albipellucida* provide a recognizable feature, and the lack of odor in this species separates it from the fragrant cultures of *Polyporus resinosus*. The rapid growth of cultures of *Poria albipellucida* on medium containing gallic acid serves to separate them from cultures of *Polyporus galactinus* in which growth is completely inhibited by gallic acid agar.

Poria asiatica (Pilât) Overholts

KEY PATTERN: (1,2) 1 (1,2) 1 9 1 2 2 (3,4) 2 2

CULTURES EXAMINED:

CANADA.—British Columbia: Clearwater, on *Thuja plicata*, 17119; Hidden Lake, on *T. plicata*, 17121; Sooke, on *T. plicata*, 11700; Upper Thompson district, on *T. plicata*, 17118, 17120; locality not known, on *T. plicata*, 11753, 11754.

CULTURAL CHARACTERS: (Pl. XV, Fig. 2; Pl. XVI, Figs. 6 and 7).

GROWTH CHARACTERS.—Growth slow to very slow, plates covered in five to six weeks or radius 5.4–8.4 cm. in six weeks. Advancing zone even, raised aerial mycelium uniform to limit of growth. Mat white, raised, cottony-floccose in newer growth, becoming more compact, woolly-felty, this type of growth extending uniformly over colony or interrupted by areas with scanty aerial mycelium, to produce a patchy appearance, with roll of cottony mycelium grown against glass in vicinity of inoculum in some isolates. Reverse unchanged. Odor of iodoform strong in most isolates when young, disappearing after three weeks. On gallic acid agar no diffusion zones, colony 1.2–2.3 cm. diameter; on tannic acid agar diffusion zones lacking or very weak, trace of growth to colony 1.3 cm. in diameter.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores very numerous in most isolates, terminal and intercalary, the walls at first thin, becoming thickened and frequently rough, variable in size and shape, 7.5–21.0 × 4.5–12.0μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores as in aerial mycelium; (*c*) crystalline material plentiful.

TYPE OF ROT: brown cubical butt and trunk rot of coniferous or, rarely, broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Buckland (38).

The chlamydospores of *Poria asiatica*, with thick, rough walls, are unique, and their occurrence makes possible the ready recognition of cultures of this species. In most other respects cultures of *P. asiatica* are remarkably similar to those of *Polyporus balsameus*, but the chlamydospores of the latter species become buffy brown in culture, and usually are sufficiently plentiful to impart this color to the mat. The key patterns of *Poria asiatica* also coincide with those for several other species, but the peculiarities of the chlamydospores permit ready separation from these species.

Poria carbonica Overholts

KEY PATTERN: 2 1 2 1 4 1 1 2 (2,3) 2 2

CULTURES EXAMINED:

CANADA.—British Columbia: Cameron Lake, on *Pseudotsuga taxifolia*, 8248, 8250; Cowichan Lake, 8215; Ladysmith, 8254, 8277; Mud Bay, 8255; Oyster River, 8269, 8271, 8278; Royston, 8247; Saanichton, 8281, 8282; Westholme, 8256, all on *P. taxifolia*.

CULTURAL CHARACTERS: (Pl. XV, Fig. 3; Pl. XVI, Figs. 6 to 9).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to six weeks. Advancing zone even, hyaline and appressed in zone up to 1.0 cm. wide. Mat white or with tinges of "pale chalcedony yellow" (9.0Y4.5/8.3), appressed, downy to woolly-felty, after three to four weeks producing raised balls of mycelium with cottony or velvety surfaces, along radii or scattered. Reverse unchanged. Odor of apples. On gallic and tannic acid agars no diffusion zones, colony 2.0–3.0 cm. diameter on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–3.0(–6.0)μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) conspicuous much-branched hyphae, the branches usually attached at right angles and frequently rebranched, the walls slightly thickened and rigid, lumina fairly broad and apparently empty, aseptate, 3.0–6.0μ diameter; (*c*) conidia numerous, borne singly at the tips of branches, which are usually narrower than the main hyphae, about 1.5μ diameter, thin-walled, broadly ovoid, slightly truncate at distal end, pointed at attached end, 7.0–9.0 × 4.5–7.0μ; (*d*) chlamydospores numerous, intercalary and terminal, walls slightly thickened, broadly ovoid, 9.0–16.5 × 7.5–12.0μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores as in aerial mycelium; (*c*) crystals numerous, octahedral.

TYPE OF ROT: brown rot of western coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Nobles (117).

The key patterns for *Poria carbonica*, showing chlamydospores, conidia, and the much-branched rigid hyphae known only in this species, stand alone in the key and the species is readily identified. Although they do not conflict in the key, mention should be made of the similarity between cultures of *Fomes officinalis* and *Poria carbonica*, both of which produce large numbers of chlamydospores and conidia. However, the special hyphae of *P. carbonica* and its more rapid rate of growth are characters by which the two species are separated in the key. In addition, *P. carbonica* has been reported only from British Columbia, Washington, and Oregon, so that it appears to be restricted to Western Canada and United States.

Poria cinerescens (Bres.) Sacc.

KEY PATTERN: (1,2) 1 1 3 9 1 2 (1,2) 2 (2,3)

CULTURES EXAMINED:

CANADA.—British Columbia: Cowichan Lake, on *Thuja plicata*, 9267, 9877; Saanichton, on *Prunus emarginata*, 17072.

The three authentic cultures of *Poria cinerescens* available for study appeared to be identical with cultures of *P. albipellucida*, and therefore, as noted under that species, a description of *P. cinerescens* has been omitted. Until means of separation have been established, cultures showing the characteristics of these species cannot be identified with certainty.

Poria colorea Overholts and Englerth

See *Poria subacida*.

Poria ferrea (Pers.) Bourd. and Galz.

KEY PATTERN: (1,2) (1,2) 1 2 9 2 2 2 3 2 (2,3)

CULTURES EXAMINED:

CANADA.—British Columbia: Duncan, on *Pseudotsuga taxifolia*, 9250; Saanichton, on *Alnus* sp., 8461, 9254, on *Pseudotsuga taxifolia*, 8243, 9256.

CULTURAL CHARACTERS: (Pl. XV, Fig. 4; Pl. XVI, Figs. 12 and 13).

GROWTH CHARACTERS.—Growth slow, plates covered in five weeks. Advancing zone even, appressed or with slightly raised tufts of aerial mycelium. Mat white with tinges of "tawny-olive" (8.0YR4.8/5.8) to "buckthorn brown" (8.0YR4.8/6.5) over inoculum, and after three to four weeks in scattered flecks or narrow zones, appressed, cottony, hyphae recumbent and radiating, sometimes grouped in slightly raised fans. Reverse unchanged for three to four weeks, then bleached. No odor. On gallic and tannic acid agars diffusion zones strong, no growth to trace on gallic acid agar, colony 1.0–2.5 cm. on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) hyphae with walls thin to slightly thickened, pale yellow to "Sudan brown" (5.5YR3.8/5.5), some frequently septate, others with long whiplashlike ends, aseptate, branched, 1.5–4.5μ diameter. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, octahedral.

TYPE OF ROT: white rot of broad-leaved and coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Baxter (12, 15).

Poria ferrea is usually described as occurring on broad-leaved trees but a number of collections in the Mycological Herbarium, Department of Agriculture, Ottawa, are from the coniferous species *Pseudotsuga taxifolia* and *Thuja plicata*. Baxter (15, p. 278) also encountered this species on conifers, and has listed cultures from *Abies* sp. and *Thuja plicata*. It is noteworthy that these reports of the occurrence of *Poria ferrea* on coniferous hosts are all from the west coast areas, British Columbia and Oregon.

Since there are three variable key characters in cultures of *Poria ferrea*, host, color of mat, and color of reverse, the species appears in eight places in the key. In four of these positions it falls with one or more other species but none of these is so similar to *P. ferrea* as to make separation difficult. In each case a descriptive key has been inserted in which differential characters are set forth.

Poria ferrugineo-fusca Karst.

KEY PATTERN: 2 2 1 2 2 2 2 2 3 2 2

CULTURES EXAMINED:

CANADA.—Ontario: Timagami, on *Picea glauca*, F1411. British Columbia: Aleza Lake, on *Abies lasiocarpa*, 16614, on *Picea glauca*, 16621. Locality and host not known, received from Bureau voor Schimmelcultures, Baarn, F7340.

CULTURAL CHARACTERS: (Pl. XV, Fig. 5; Pl. XVI, Figs. 14 and 15).

GROWTH CHARACTERS.—Growth slow, plates covered in five weeks. Advancing zone even, appressed, hyaline. Mat "avellaneous" (8.0YR6.2/3.5) and "wood brown" (7.0YR5.7/4.0) (one week), with overgrowth of "honey yellow" (2.0Y6.7/5.2) to "ochraceous-tawny" (6.0YR4.9/6.3) (six weeks), at first with aerial mycelium scanty, then cottony, finally compact woolly with scattered small balls or granules, producing rough surface, with drops of colorless exudate. Reverse unchanged. Odor none. On gallic acid agar diffusion zone strong, on tannic acid agar diffusion zone very weak to moderately strong, no growth or only a trace on either medium.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with occasional simple septa, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) setal hyphae very numerous, giving color to mat, pale greenish-yellow to "cinnamon-brown" (5.0YR 3.0/3.0) and "Prout's brown" (5.5YR2.8/3.2) in potassium hydroxide, long, flexible, curving, 4.5–6.0μ diameter, tapering to sharp point. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, octahedral.

TYPE OF ROT: yellow ring rot of coniferous trees.

Poria ferrugineo-fusca falls close to *P. Weirii* in the key, but is distinguishable from it by its slower growth rate. The topography of the cultures of the two species differs also, the mat of *P. ferrugineo-fusca* being thin in newer growth, raised in the older part, while that of *P. Weirii* is raised in the newer part, and tends to become collapsed in older parts. These differences in type of growth result in noteworthy differences in appearance of mature cultures.

Poria ferruginosa (Schrad. ex Fries) Karst.

KEY PATTERN: (1,2) 2 1 2 2 2 2 2 4 2 1

CULTURES EXAMINED:

CANADA.—Quebec: Mt. Burnet, on broad-leaved tree, 11253. UNITED STATES.—Massachusetts: October Mountain, on *Fraxinus* sp., 9513.

CULTURAL CHARACTERS: (Pl. XV, Fig. 6; Pl. XVI, Figs. 16 to 18).

GROWTH CHARACTERS.—Growth very slow, radius 4.0–7.0 cm. in six weeks. Advancing zone with shallow bays, the aerial mycelium uniform to limit of growth. Mat white at first and remaining so over most of surface or only in narrow zone, changing to "honey yellow" (2.0Y6.7/6.2), "sayal brown" (7.0YR5.0/5.5), "Saccardo's umber" (9.0YR3.8/3.5), with flecks of "ochraceous-tawny" (6.0YR4.9/6.3) (one to six weeks) over most of surface or in restricted zone around inoculum, appressed, downy to thin felty, occasionally with slightly more compact growth in fan-shaped areas. Reverse unchanged below white parts of mat, "ochraceous-tawny" (6.0YR4.9/6.3) to "buckthorn brown" (8.0YR4.8/6.5) below colored areas. No odor. On gallic and tannic acid agars diffusion zones moderately strong to strong, trace of growth to colony 1.0 cm. diameter on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, hyaline to dilute brown, frequently branched and anastomosed; (*b*) setae or setal hyphae numerous, thick-walled, dark brown, pointed, elongate, 90.0–200.0 $\times$ 4.5–6.0μ, frequently the end of a dark brown hypha. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot of broad-leaved and, rarely, coniferous trees.

The elongate setae or setal hyphae of *Poria ferruginosa* are distinct from the short setae of *Fomes Pini* and *Polyporus circinatus*, and also from the broader setal hyphae of *Polyporus glomeratus*, cultures of which, in addition, exhibit a pseudoparenchymatous layer not found in *Poria ferruginosa*. It is possible, therefore, to separate *P. ferruginosa* from these other species having identical key patterns.

Poria microspora Overholts

See *Poria monticola*.

Poria monticola Murr.

KEY PATTERN: (1,2) 1 2 1 9 1 2 2 (1,2) (1,2) 2

CULTURES EXAMINED:

CANADA.—British Columbia: Queen Charlotte Islands, on *Picea sitchensis*, F347, F458, 10724, 10726, 11712, 11713, 11714; Vancouver, on *Tsuga heterophylla*, 9251. Original locality not known, isolated from decay in building timber (*Pinus Banksiana*), 8191 (*Pinus* sp.), 11620, 11179 (*Pseudotsuga taxifolia*), F7640, 9176, 9429, 9511 (coniferous timber), F1280, F8009.

CULTURAL CHARACTERS: (Pl. XV, Fig. 7; Pl. XVI, Figs. 19 to 24).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to four weeks. Advancing zone even, appressed and hyaline in some isolates, or with raised aerial mycelium extending to limit of growth. Mat white or with tinge of pale "cartridge buff" (3.0Y8.5/2.2) to "cinnamon-buff" (9.0YR6.6/5.8) at edges, slightly raised, loosely arranged, cottony to woolly, frequently grown against sides of Petri dish and across lid, forming scattered fruit bodies after two to three weeks in some isolates, these consisting of waxy granules or plates coalescing to form foliose or, more rarely, irregularly pored fruiting surfaces, which produce copious spore deposits. Reverse unchanged. Odor none. On gallic and tannic acid agars no diffusion zones, diameter 3.0–5.6 cm. on gallic acid agar, no growth or only a trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–6.0μ diameter. *Aerial mycelium:* (*a*) nodose-septate hyphae as in advancing zone, in some isolates occasionally up to 8.0–16.5μ diameter, with walls irregularly thickened and lumina relatively narrow; (*b*) chlamydospores rare to numerous, with walls slightly thickened, contents staining deeply in phloxine, intercalary or terminal, 8.0–19.5 × 6.0–13.5μ. *Fruit body:* (*a*) nodose-septate hyphae as in advancing zone; (*b*) basidia 13.0–18.0 × 4.5–6.3μ, bearing four sterigmata and spores; (*c*) basidiospores hyaline, even, oblong-ellipsoid, apiculate, somewhat flattened on one side, 4.5–6.3 × 2.2–2.7μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) hyphae with thick walls and irregular swellings up to 16.5μ diameter, found only in older cultures; (*c*) crystals numerous, octahedral.

TYPE OF ROT: brown cubical rot of coniferous and broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright (48, under *Trametes serialis*), Cartwright and Findlay (54, under *T. serialis*; 56, under *Poria microspora*), Nobles (117, under *Poria microspora*), Snell (139, under *Trametes serialis*).

This fungus, described as *Poria microspora* by Overholts in a paper by the author (Nobles (117)), was subsequently found by Overholts (124) to be identical with a part of the type collection of *Poria monticola* Murr. Hence the name *Poria microspora* must be reduced to synonymy under *Poria monticola*.

The faintly pinkish tinge of the mycelium, frequently too pale to be identified in Ridgway's scale, and the early formation of characteristic foliose fruit bodies with heavy spore deposits in most isolates, serve to differentiate this fungus from other species. A few isolates produced an abundant growth of aerial mycelium and failed to form fruit bodies during the period of examination. In the key these have been separated from other species with identical key patterns on the basis of color and type of chlamydospores.

Poria monticola may persist in wood in service and prove to be very destructive (Hirt and Lowe (86)). It is frequently encountered among cultures isolated from decay in building timbers.

Poria obliqua (Pers. ex Fries) Bres.

KEY PATTERN: 1 2 1 2 2 2 2 2 3 1 (1,2)

CULTURES EXAMINED:

CANADA.—Nova Scotia: Kentville, on *Betula* sp., F2277. New Brunswick: Fredericton, on *B. lutea*, F1384. Quebec: Mt. St. Gregoire, on *B. lutea*, F5558. Ontario: Kathmore, on *Ostrya virginiana*, F7403; Petawawa, on *Betula papyrifera*, F7449. UNITED STATES.—Pennsylvania: Hunt County, on *Betula* sp., F1705.

CULTURAL CHARACTERS: (Pl. XV, Fig. 8; Pl. XVI, Figs. 25 to 29).

GROWTH CHARACTERS.—Growth slow, plates covered in five to six weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white (one week), the older part becoming "straw yellow" (5.0Y9.0/5.5) and "reed yellow" (7.0Y7.8/6.2) (two weeks), to "amber yellow" (4.0Y7.7/7.0), "mustard yellow" (2.0Y7.8/7.5), and "antimony yellow" (1.0Y6.5/7.0) (three weeks), the newest growth raised, loosely arranged, cottony, the older part in some isolates collapsed and so thin as to allow color of agar to show through, in other isolates thin felty and opaque, fruiting after four to six weeks in more compact raised areas, scattered or in zones, "yellow ocher" (10.0YR6.8/9.0) to "buckthorn brown" (8.0YR 4.8/6.5), with surface irregularly pored. Reverse in some isolates unchanged, in others "buckthorn brown" (8.0YR4.8/6.5) to "argus brown" (5.5YR3.3/5.0) below oldest parts. On gallic and tannic acid agars diffusion zones very weak to weak, no growth on gallic acid agar, none to trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with thin walls and simple septa, 2.0–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, "gradually grading into yellowish many-septate hyphae in older portions of the mat"; (*b*) setal hyphae, with walls and contents dark brown, occasionally septate, pointed, of varying lengths, 1.5–7.5μ diameter. *Fruit body:* (*a*) hyphae as in aerial mycelium; (*b*) setae with walls thick, hyaline to brown, the base bulbous and tip pointed, 6.0–9.0μ diameter; (*c*) basidia subglobose to short clavate, with numerous conspicuous oil globules, bearing four sterigmata and spores; (*d*) basidiospores hyaline to yellowish, one guttulate, ovoid, slightly flattened on one side, 6.0–9.0 $\times$ 4.0–4.5μ. *Submerged mycelium:* hyphae as in aerial mycelium.

TYPE OF ROT: white rot of broad-leaved trees, usually *Betula* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42, under Sterile *Fomes*), Campbell and Davidson (44), Cartwright and Findlay (55, 56), Davidson, Campbell, and Blaisdell (64), Findlay (71).

Poria obliqua falls alone in the key, being separated from the similar *Polyporus gilvus* by the slower growth rate of *Poria obliqua*. Cultures of *P. obliqua* exhibit a number of distinctive characters, by which they can be readily identified, the brown fruiting surface being especially noteworthy.

Poria punctata Fries

KEY PATTERN: 1 2 1 2 9 2 2 2 3 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Merrifield's Corners, on *Salix* sp., F1563; Timagami, on *Acer* sp., F1402.

CULTURAL CHARACTERS: (Pl. XV, Fig. 9; Pl. XVI, Figs. 30 to 32).

GROWTH CHARACTERS.—Growth slow, plates covered in five to six weeks. Advancing zone even, white, slightly raised aerial mycelium extending to limit of growth. Mat white at first and border remaining so until mat has covered plate, becoming "pinkish buff" (9.0YR 7.3/4.5), "chamois" (2.0Y7.5/5.8), and "tawny-olive" (8.0YR4.8/5.8) after two to three weeks, raised to top of Petri dish in vicinity of inoculum and gradually sloping to level of agar at margin, thick woolly, sometimes with layer of mycelium growing across inside of lid of Petri dish. Reverse unchanged. No odor. On gallic acid agar diffusion zones very strong, no growth; on tannic acid agar diffusion zones strong, colony 2.5 cm. diameter.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with conspicuous simple septa, 1.5–4.5μ diameter. *Aerial mycelium:* hyphae as in advancing zone, hyaline to brown, with rare simple septa, but with long fiberlike ends lacking septa and branches, 1.5–2.0μ diameter. *Submerged mycelium:* hyphae hyaline, frequently branched, the branches often short and curving, with simple septa, 1.5–3.0μ diameter.

TYPE OF ROT: white rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64).

In the key, *Poria punctata* falls along with *Polyporus dryophilus* var. *vulpinus* and *Poria ferrea*, from which it is readily separated on the basis of its macroscopic appearance. In *Poria punctata* the mat becomes thicker with increasing age, being finally grown to top of Petri dish and frequently across inner surface of the lid of the Petri dish; in *Polyporus dryophilus* var. *vulpinus* the newest growth is most raised, the older portions of the mat becoming collapsed and felty; in *Poria ferrea*, the mat is all appressed. In addition, *Polyporus dryophilus* var. *vulpinus* occurs on *Populus* spp. only, while the other species occur on a variety of broad-leaved trees.

Poria rufa (Schrad. ex Fries) Cooke

Poria taxicola (Pers.) Bres.

KEY PATTERN: 2 1 2 4 9 2 2 2 1 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Old Chelsea, on conifer, 11252. British Columbia: Aleza Lake, on *Abies lasiocarpa*, 16564, 16615, 16616, on *Picea glauca*, 16560, 16617.

CULTURAL CHARACTERS: (Pl. XV, Fig. 10; Pl. XVI, Figs. 33 and 34).

GROWTH CHARACTERS.—Growth rapid, plates covered in two weeks. Advancing zone even, slightly raised aerial mycelium extending to limit of growth. Mat white, the newest growth raised, cottony-floccose, becoming collapsed, thin downy, the aerial mycelium almost lacking in some isolates, with overgrowth of small compact balls or tufts in certain sectors. Reverse unchanged. No odor. On gallic and tannic acid agars no diffusion zones, colony 1.0–4.0 cm. diameter on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with walls so thin and fragile that the hyphae become twisted and distorted when mounted in potassium hydroxide solution, with occasional single or double clamp connections and inconspicuous simple septa, frequently

branched, 3.0–7.5μ diameter. *Aerial mycelium:* hyphae as in advancing zone, with clamp connections rare, 2.2–4.5(–6.0)μ diameter. *Submerged mycelium:* hyphae as in aerial mycelium, occasionally much-branched to produce a witches' broom effect.

TYPE OF ROT: yellow rot of coniferous trees.

Poria rufa keys out with *Coniophora puteana* but is readily separated from that species by its scantier production of aerial mycelium, its fragile hyphae with rare, inconspicuous, multiple clamp connections in contrast with the large whorls of clamp connections noticeable on the hyphae of the advancing zone of *Coniophora puteana*, and its association with a white or pale yellow rot while that caused by *C. puteana* is a brown cubical rot.

Poria subacida (Peck) Sacc.

KEY PATTERN: (1,2) 1 1 1 9 2 2 2 (1,2) 2 (2,3)

CULTURES EXAMINED:

CANADA.—Quebec: Champlain County, on *Picea glauca*, 10258, 10259; Lac Humqui, on *Abies balsamea*, F308; Maniwaki, on *Picea mariana*, 9341, 9770, 9771. Ontario: Timagami, on *Abies balsamea*, F598. British Columbia: Cowichan Lake, on *Thuja plicata*, 11690, 11698; Mission, on *T. plicata*, 9334; Queen Charlotte Islands, on *Picea sitchensis*, 10720, 10737, 11715, on *Tsuga heterophylla*, 10721; Saanichton, on *Pseudotsuga taxifolia*, 9762. UNITED STATES.—Alaska, on *Picea sitchensis*, 11687.

CULTURAL CHARACTERS: (Pl. XV, Fig. 11; Pl. XVI, Figs. 35 and 36).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in two to three weeks. Advancing zone even, appressed and hyaline in narrow zone, or with slightly raised aerial mycelium extending to limit of growth. Mat white, in newer growth slightly raised, thin woolly, in area around inoculum appressed, so thin as to be translucent, later raised, uniformly cottony-woolly to felty over whole surface, sometimes grown to top of Petri dish at edge, frequently with minute papillae where mat is grown against side of Petri dish. Reverse unchanged or bleached after five to six weeks. Odor none. On gallic acid agar diffusion zones moderately strong to strong, trace of growth; on tannic acid agar diffusion zones weak to moderately strong, up to 3.0 cm. diameter.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–5.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous, walls thick and refractive, lumina narrow or apparently lacking, rarely branched, aseptate, long, curving, closely interwoven, 1.5–3.0μ diameter. *Submerged mycelium:* (*a*) hyphae as in advancing zone, frequently branched; (*b*) crystals numerous, octahedral.

TYPE OF ROT: white rot (feather rot, spongy root rot, stringy butt rot) of coniferous and broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Fritz (74), Humphrey and Siggers (92).

In the present study, cultures of *Poria subacida* and *P. colorea* appeared to be identical in their cultural characters, so that it was not possible to separate the species. The key patterns for *P. subacida* coincide with those for several other species, most of which lack distinctive diagnostic characters, so that it is difficult to find bases for descriptive keys and positive identifications. *Poria subacida* cultures resemble those of *Fomes pinicola* in their lack of distinctive markings, and this lack, together with the positive reaction on gallic and tannic acid agars, makes it possible to recognize cultures of *Poria subacida* when one has become familiar with them.

Poria taxicola (Pers.) Fries

See *Poria rufa*.

Poria tsugina (Murr.) Sacc. and Trott.

KEY PATTERN: 2 2 1 2 (6,9) 2 2 2 4 2 1

CULTURES EXAMINED:

CANADA.—Quebec: Old Chelsea, on *Tsuga canadensis*, 11598. British Columbia: Oyster River, on *Tsuga heterophylla*, 8445; Shaw Creek, on *T. heterophylla*, 8219; Vancouver, on *T. heterophylla*, 8744. UNITED STATES.—Pennsylvania: Cooke Forest, on *Tsuga* sp., F1702.

CULTURAL CHARACTERS: (Pl. XV, Fig. 12; Pl. XVI, Figs. 37 to 39).

GROWTH CHARACTERS.—Growth very slow, radius 3.5–7.5 cm. in six weeks. Two different types of growth may occur in different isolates, in the same isolate in successive plantings, or in different sectors or zones of a colony.—(*a*) Advancing zone even, with aerial mycelium uniform to limit of growth. Mat white at margin, changing to "cream color" (3.0Y8.6/4.5), "straw yellow" (5.0Y9.0/5.5), "honey yellow" (2.0Y6.7/6.2), "tawny-olive" (8.0YR 4.8/5.8), the newest growth slightly raised, short cottony, becoming opaque woolly, tufted, with brittle, crustose areas "Saccardo's umber" (9.0YR3.8/3.5) in color formed after three to six weeks, the growth of the aerial mycelium apparently inhibited after five to six weeks. Reverse "buckthorn brown" (8.0YR4.8/6.5), "cinnamon-brown" (5.0YR3.0/3.0), "mummy brown" (7.5YR2.5/2.3), after five to six weeks the color in agar extending beyond aerial mycelium, and apparently being correlated with inhibition of growth. (*b*) Advancing zone even, appressed, hyaline mycelium over dark brown diffusion zone that extends to limit of growth or beyond. Mat "yellow ocher" (10.0YR6.8/9.0) to "antique brown" (8.0YR 4.2/5.5), thin cottony, so sparse as to allow darker color of agar to show through and mask color of mat. Reverse "buckthorn brown" (8.0YR4.8/6.5), "cinnamon-brown" (5.0YR3.0/3.0), "mummy brown" (7.5YR2.5/2.3). No odor. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, no growth or a trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, thin-walled, with simple septa, frequently branched, 1.5–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, hyaline to pale yellow or dark brown, with walls slightly thickened, branched, 3.0–4.5μ, diameter; (*b*) brown hyphae with walls somewhat thickened, with rare, simple septa, branched but with long unbranched fiberlike ends, 1.0–2.2μ diameter; (*c*) brown hyphae with clublike or knoblike projections, firmly interlocked to form a pseudoparenchymatous crustose layer. *Submerged mycelium:* hyphae as described in (*a*) above, becoming paler with increasing depth in agar.

TYPE OF ROT: white rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Campbell (42, under *Fomes robustus* var. *tsugina*), Davidson, Campbell, and Blaisdell (64, under *F. robustus* var. *tsugina*).

If the characteristic hyphae making up the pseudoparenchymatous layer are observed and included in the key pattern, then *Poria tsugina* stands alone in the key and should be readily identified. If these special structures are omitted from the key pattern, it falls along with *Fomes nigrolimitatus* and *Polyporus dryadeus*. A descriptive key, which notes general appearance and distribution, has been included to facilitate the separation of these species.

Poria Vaillantii (Fries) Cooke

KEY PATTERN: 2 1 2 1 9 2 2 2 2 (1,2) 2

CULTURES EXAMINED:

CANADA.—Quebec: Foster, on beam in house, F5946. Locality and host not known, received from Forest Products Research Laboratory, Princes

Risborough, England, 10444; received from Division of Forest Pathology, United States Department of Agriculture, 11740; received from Bureau voor Schimmelcultures, Baarn, F7319.

CULTURAL CHARACTERS: (Pl. XV, Fig. 13; Pl. XVI, Figs. 40 to 42).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, raised aerial mycelium extending to limit of growth. Mat white, slightly raised, cottony-woolly, frequently with strands originating at inoculum and extending across surface or around edge of plate and expanding in plumelike structures, usually bearing fragile, pored fruit bodies after three to four weeks. Reverse unchanged. Odor slight. On gallic and tannic acid agars no diffusion zones, colony 3.0–6.0 cm. diameter on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae numerous in strands and fruiting surface, with walls thick and refractive, lumina apparently lacking, unbranched, aseptate, 2.2–3.0μ diameter. *Fruit body:* (*a*) nodose-septate hyphae and (*b*) fiber hyphae as described above; (*c*) basidia 6.0–7.5μ diameter, bearing four spores; (*d*) basidiospores hyaline, even, oblong-ellipsoid, slightly flattened on one side, usually with one large conspicuous oil drop, 4.5–6.0 × 3.0–3.5μ. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, octahedral.

TYPE OF ROT: brown cubical rot of coniferous trees, usually on "boards and other forms of structural timber in damp situations".

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (51, 52, 54, 56), Davidson, Campbell, and Blaisdell (64), Walek-Czernecka (150).

Cartwright and Findlay (54) discussed the "confusion about the identity of this and other related species of *Poria*" and concluded that "In view of the fact that a number of different plants have been included under the name *Poria vaporaria*, it has been decided to apply the name *P. vaillantii* to the fungus which is a frequent cause of dry rot in Great Britain." The cultures used in the present study include one received from Dr. Cartwright of the Forest Products Research Laboratory in England, an American isolate received from Mr. R. W. Davidson of the Division of Forest Pathology of the United States Department of Agriculture, and other isolates from Ottawa. These are all identical, which indicates that the American concept of the species agrees with that adopted by Cartwright and Findlay.

The key patterns for *P. Vaillantii* coincide with those for several other species, but the unusual appearance of the cultures, with their plumelike growth, noted in the descriptive key, allows for separation. In addition, cultures of this species will be encountered most frequently as isolates from decay in wood in service.

Poria Weirii Murr.

KEY PATTERN: 2 2 1 2 2 2 2 2 2 2 (2,3)

CULTURES EXAMINED:

CANADA.—British Columbia: Cowichan Lake, on *Pseudotsuga taxifolia*, F1277, 8186, 8221, 8231, 8470, 9269, 9316, 9323, 9422, 9278, on *Tsuga heterophylla*, 8205, 8288; Lumby, on *Thuja plicata*, 8734. UNITED STATES.—Locality not known, on *T. plicata*, 8754.

CULTURAL CHARACTERS: (Pl. XV, Fig. 14; Pl. XVI, Figs. 43 to 45).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three weeks. Advancing zone even, sharply delimited, raised aerial mycelium extending to limit of growth. Mat white at first, changing to "tilleul-buff" (9.0YR8.7/1.5), "vinaceous-buff" (7.0YR7.0/3.5), "avellaneous" (8.0YR6.2/3.5), and "wood brown" (7.0YR5.7/4.0), or "cream-buff" (3.0Y8.3/4.5) and "chamois" (2.0Y7.5/5.8) (two weeks), in some isolates becoming "honey yellow" (2.0Y6.7/6.2) and "tawny-olive" (8.0YR4.8/5.8) (four weeks), the color evenly distributed or limited to certain zones, slightly raised, cottony in newest growth, becoming somewhat flattened and woolly, in some isolates producing small areas crustose in texture and "tawny-olive" (8.0YR4.8/5.8) to "Saccardo's umber" (9.0YR3.8/3.5) in color. Reverse unchanged or bleached after three to four weeks. Odor strong and unpleasant at first, but no longer perceptible after four to five weeks. On gallic and tannic acid agars diffusion zones moderately strong, colonies 2.0–4.5 cm. diameter on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with simple septa, branched, 2.2–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) hyphae yellow to brown in potassium hydroxide solution, with walls slightly thickened, frequently septate, branched, 2.2–4.5μ diameter, frequently ending in setal hyphae; (*c*) setal hyphae numerous in all parts of mat, slender, tapering to a point, with walls thick and dark brown, 4.5–6.0(–7.5)μ diameter, up to 350μ long. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) crystals numerous, octahedral.

TYPE OF ROT: yellow ring rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Mounce, Bier, and Nobles (112).

Poria Weirii stands alone in the key and so should be readily identifiable. To date it has been reported only from Idaho, Oregon, Washington, and British Columbia, where it has been found causing a laminate butt and root rot of several species of coniferous trees.

Poria xantha (Fries) Cooke

KEY PATTERN: (1,2) 1 2 1 9 (1,2) 2 2 2 (1,2) 2

CULTURES EXAMINED:

CANADA.—British Columbia: Aleza Lake, on *Picea glauca*, 16630, 16645, 16647, on conifer, 16629; Blue River, on *Tsuga heterophylla*, 16088; Cowichan Lake, on *Pseudotsuga taxifolia*, 9315; Prince George, on *Abies* sp., 16570, 16571; Queen Charlotte Islands, on *Picea sitchensis*, 16029; Sooke, on *Tsuga heterophylla*, 16089.

CULTURAL CHARACTERS: (Pl. XV, Fig. 15; Pl. XVI, Figs. 46 to 48).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three to four weeks. Advancing zone even, raised, scattered cottony fibers to limit of growth. Mat white, the newest growth raised, loosely arranged, cottony, then abruptly collapsed, aerial mycelium lacking, leaving shining surface, or limited to thin translucent film, sometimes with patches of cottony mycelium scattered over surface, and usually with cottony mycelium grown against walls of Petri dish remote from inoculum to top of dish, in some isolates forming minutely pored fruiting surfaces after five to six weeks. Reverse unchanged. No odor. On gallic and tannic acid agars no diffusion zones (may be slight browning below inoculum), colony 2.0–6.0 cm. diameter on gallic acid agar, no growth or a trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 3.0–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently with walls or small parts of wall thickened and refractive, often broken into short lengths; (*b*) nonstaining segments of nodose-septate hyphae, with walls evenly thickened but lumina still visible, 1.2–3.1μ diameter; (*c*) chlamydospores rare or apparently lacking, usually intercalary, rarely terminal, with walls slightly thickened, 10.5–19.5 × 6.0–7.5μ. *Fruit body:* (*a*) basidia 3.7μ diameter, bearing four spores; (*b*) basidiospores hyaline, even, cylindric, slightly curved, 4.2–5.0 × 1.2μ. *Submerged mycelium:* hyphae as in aerial mycelium.

TYPE OF ROT: brown cubical rot of coniferous and broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (56), Davidson and Campbell (63), Humphrey and Siggers (92).

Each of the eight key patterns for *Poria xantha* falls with a group of species with identical key patterns. In the inserted descriptive keys separations are based, in the main, on the topography and color of mats. The appearance of cultures of *P. xantha* is characteristic, the surface of older cultures appearing glazed, with aerial mycelium piled up at the edge of the Petri dish and frequently bearing fruiting surfaces.

Schizophyllum commune Fries

KEY PATTERN: 1 1 (1,2) 1 9 (1,2) 2 2 2 (1,2) 2

CULTURES EXAMINED:

CANADA.—Quebec: Wakefield, 11795. Ontario: Ottawa, 11790. Locality not known, on *Betula* sp., F2327. UNITED STATES.—Locality and host not known, F2961.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 1; Pl. XVIII, Figs. 1 to 4).

GROWTH CHARACTERS.—Growth moderately rapid, plates covered in three weeks. Advancing zone even, except for fans of mycelium extending along edge of Petri dish in advance of periphery of colony and then growing in to meet advancing margin, raised aerial mycelium uniform to limit of growth. Mat white, raised, woolly, frequently grown against wall of Petri dish and down between bottom and lid of dish, with scattered, more or less compact, raised lumps appearing after two to three weeks, some of which develop into fruit bodies that may be normal, i.e. similar to those produced in nature, or much distorted. Reverse unchanged. Odor lacking in young cultures, like honey in six-weeks-old cultures. On gallic acid agar no diffusion zones, on tannic acid agar diffusion zones weak, colonies 3.5–4.4 cm. diameter on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, the cells short, the clamp connections lying close together, 2.2–4.5μ diameter. *Aerial mycelium:* (tough, coherent) (*a*) hyphae as in advancing zone, occasionally with walls somewhat thickened and hyphae then nonstaining, 1.5–6.0μ diameter; (*b*) hyphae as in advancing zone but with numerous minute projections at right angles to cell wall, 2.2–4.5μ diameter; (*c*) chlamydospores fairly numerous in some isolates, rare or apparently lacking in others, terminal and intercalary, with walls slightly thickened, 6.0–15.0 × 4.5–7.5μ. *Submerged mycelium:* (*a*) nodose-septate hyphae and (*b*) chlamydospores as in aerial mycelium.

TYPE OF ROT: white sap rot of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Cartwright and Findlay (52), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Vaughn (67), Humphrey and Siggers (92), Putterill (127).

Cultures of *Schizophyllum commune* are unusual in that they consistently produce no diffusion zones on gallic acid agar but give a positive reaction on tannic acid agar. This necessitates the inclusion of the species in the key in the group of fungi showing positive reaction on these media and also in the group of species having no diffusion zones. Cultures occasionally fail to form chlamydospores and also to produce fruit bodies within the six weeks' period during which they are under observation. Hence the species appears in the key as having and also as lacking chlamydospores, as fruiting and not fruiting. Each of its eight key patterns coincides with that of one or more other species but identification can be made readily since *S. commune* is

unique in its reaction on gallic and tannic acid agars and in the production of characteristic hyphae having minute projections. Davidson, Campbell, and Vaughn (67) describe these as "short granular side branches" but refer to Vanin who considered them to be "granular crystals'. Careful observation leads to the conclusion that the walls of the projections are continuous with the cell wall and that they are in fact "side branches".

Stereum abietinum Pers.

KEY PATTERN: 2 2 2 3 9 1 2 2 4 2 1

CULTURES EXAMINED:

CANADA.—British Columbia: Alberni, on coniferous tree, 16603, 16604; Queen Charlotte Islands, on *Picea sitchensis*, 16090, 16092, on *Tsuga heterophylla*, 16091. UNITED STATES.—Locality and host not known, 11758, 11792.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 2; Pl. XVIII, Figs. 5 to 8).

GROWTH CHARACTERS.—Growth very slow, radius 6.0–7.7 cm. in six weeks. Advancing zone even, appressed and hyaline so that it is difficult to see limit of growth. Outer zone about 1 cm. broad, hyaline, with scanty appressed film of mycelium over agar, next zone "cinnamon-buff" (9.0YR6.6/5.8) and "tawny-olive" (8.0YR4.8/5.8) with aerial mycelium almost completely lacking except for "tawny-olive" woolly mycelium over inoculum. Reverse unchanged below newest growth, then "cinnamon-brown" (5.0YR3.0/3.0), "Mars brown" (4.5YR2.8/3.0), with numerous, conspicuous, opaque, dark brown dots at all levels within agar. Odor lacking in young cultures, penetrating and disagreeable in five- to six-weeks-old cultures. On gallic and tannic acid agars no diffusion zones (agar may become brown below inoculum as on malt agar), no growth or only a trace.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, with rare, inconspicuous, simple septa, 2.2–4.5μ diameter. *Aerial mycelium:* (scanty, mounts scraped from surface) (*a*) hyphae usually hyaline, rarely with golden brown or dark brown contents, most septa with clamp connections although simple septa, incomplete clamp connections, and normal clamp connections may occur in the same hypha, 2.2–4.5μ diameter; (*b*) hyphae with walls thickened and yellow, lumina narrow but broadening at tip, which may show one or two constrictions, these usually being terminal cells of hyphae as described in (*a*); (*c*) chlamydospores numerous, usually terminal but occasionally intercalary, contents hyaline to golden brown, walls at first thin, finally fairly thick, globose to subglobose, 9.0–12.0 × 9.0–10.5μ. *Submerged mycelium:* (*a*) hyaline hyphae and (*b*) chlamydospores as described above.

TYPE OF ROT: brown cubical rot of coniferous trees.

When one has become familiar with cultures of *Stereum abietinum*, they can be recognized at sight by the characteristic opaque brown dots within the agar, conspicuous in colonies growing in Petri dishes and in culture tubes. In addition, the unusual combination of characters of a brown culture having a negative reaction on gallic and tannic acid agars, and the distinctive hyphae, make cultures of the species easy to key out and identify.

Stereum Murraii (Berk. and Curt.) Burt

KEY PATTERN: 1 1 1 1 9 2 2 2 4 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Gatineau Park, on *Betula papyrifera*, 11362; Mt. Burnet, on *Ostrya virginiana*, F3463.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 3; Pl. XVIII, Figs. 9 and 10).

GROWTH CHARACTERS.—Growth very slow, radius 2.6–4.0 cm. in six weeks. Advancing zone even, sharply delimited, slightly raised aerial mycelium extending to limit of growth. Mat white, slightly raised, aerial mycelium at first short cottony, later furlike, i.e., fibers short, straight, lying parallel, having a combed appearance, velvety over oldest part, somewhat zonate but thick enough in all parts to be opaque. Reverse unchanged. Odor fairly strong, suggesting rotting apples. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, trace to 1.5 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) fiber hyphae fairly numerous, frequently branched, aseptate, with walls thick and refractive, 1.0–1.5μ diameter. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white rot and cankers of broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Davidson, Campbell, and Blaisdell (64), Davidson, Campbell, and Lorenz (65).

In the key, *Stereum Murraii* coincides with only one other species, *Fomes ohiensis*, their slow rate of growth separating them from all other species with similar characteristics. Macroscopically, cultures of *F. ohiensis* and *Stereum Murraii* are different, the former being appressed, farinaceous, with dots of more compact mycelium, the latter being slightly raised, furry or velvety, all compactly arranged and opaque.

Stereum sanguinolentum Alb. and Schw. ex Fries

KEY PATTERN: 2 1 1 4 (1,9) 2 2 2 (2,3) 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Champlain County, on *Picea mariana*, 10277; Lac Vert, on *P. mariana*, 10286, 10287, 10288; Mt. Burnet, on coniferous wood, F6510. British Columbia: Aleza Lake, on *Abies* sp., 16587, 16588, 16618; Cowichan Lake, on *Pseudotsuga taxifolia*, 9276; Green Timbers, on *Pinus ponderosa*, 9330; Hidden Lake, on *Thuja plicata*, 16665; Vancouver, on conifer, 9504.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 4; Pl. XVIII, Figs. 11 to 14).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in three to five weeks. Advancing zone even or with broad, shallow bays, with sparse, cottony mycelium extending to limit of growth. Mat white at first and remaining so or becoming "cream color" (3.0Y8.6/4.5) to "chamois" (2.0Y7.5/5.8) (four to six weeks), slightly raised, the newer growth downy to cottony-floccose, translucent, the older part felty, opaque. Reverse unchanged to about "honey yellow" (2.0Y6.7/6.2). Odor sweet. On gallic and tannic acid agars diffusion zones moderately strong to strong, trace of growth to colony 1.0 cm. diameter on gallic acid agar, trace of growth to colony 2.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, the septa usually simple but occasionally with large clamp connections on the broader hyphae, occurring singly or in pairs at a septum, 2.2–6.0μ diameter. *Aerial mycelium:* (*a*) hyphae hyaline, with simple septa, frequently branched, 1.5–4.5(–6.0)μ diameter; (*b*) cystidiumlike structures, probably analogous to 'conducting cells' of fruit bodies, being expanded ends of hyphae, with walls thickened and refractive, contents at first hyaline and staining in phloxine, then dark brown, 4.5–7.5μ diameter, plentiful in some isolates, rare or apparently lacking in others. *Submerged mycelium:* (*a*) hyphae as in aerial mycelium; (*b*) crystals large, octahedral.

TYPE OF ROT: brown heart rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Cartwright and Findlay (54, 56), Fritz (74), Robak (134).

The key patterns for *Stereum sanguinolentum*, showing the presence of multiple clamp connections on hyphae of the advancing zone, occur alone in the key. Hence, if the nature of the septation is observed in an unidentified culture of this species, it should be possible to key it out readily.

Trametes americana Overholts

KEY PATTERN: 2 1 2 (1,2) 9 (1,2) 2 (1,2) (2,3) 2 2

CULTURES EXAMINED:

CANADA.—Quebec: Eagle Depot, on *Pinus Banksiana*, 9527; Mt. Burnet, on coniferous wood, 11789. British Columbia: Cowichan Lake, on *Pseudotsuga taxifolia*, 8216. Locality and host not known, 8189, 8190, 9414.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 5; Pl. XVIII, Figs. 15 to 18).

GROWTH CHARACTERS.—Growth moderately rapid to slow, plates covered in four to six weeks. Advancing zone even, hyaline and appressed. Two different types of growth may occur in different isolates, in the same isolate in successive plantings, or in different sectors or zones of a colony: (i) mat white and remaining so or becoming "cream-buff" (3.0Y8.3/4.5), "chamois" (2.0Y7.5/5.8), and "honey yellow" (2.0Y6.7/6.2) over oldest parts, at first short cottony, later woolly, opaque; (ii) mat white, appressed, farinaceous, so thin as to be translucent, this type of mat growing slightly more rapidly than type (i); (iii) mats showing both types of growth, either in sectors, or in zones, the farinaceous type surrounding the cottony-woolly growth. Reverse unchanged. Odor sweet. On gallic and tannic acid agars no diffusion zones, colony up to 1.5 cm. diameter on gallic acid agar, no growth on tannic acid agar.

HYPHAL CHARACTERS.—(Of two types, correlated with the types of growth described above) (i) *Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 2.2–4.5μ diameter. *Aerial mycelium:* hyphae as in advancing zone. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores fairly numerous, terminal and intercalary, 9.0–21.0 × 7.5–10.5μ. (ii) *Advancing zone:* hyphae hyaline, with simple septa, 1.5–3.0(–4.5)μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone; (*b*) oidia numerous, formed by fragmentation of simple septate hyphae, 1.5–3.0μ diameter, of varying lengths. *Submerged mycelium:* (*a*) hyphae as in advancing zone; (*b*) chlamydospores rare, as described above.

TYPE OF ROT: brown cubical rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Mounce and Macrae (113), Snell, Hutchinson, and Newton (140, under *Trametes proctracta*).

Cultures of *Trametes americana* exhibit so much variation in macroscopic and microscopic characters as to make their recognition difficult. New isolates have, usually, fairly uniform, cottony to woolly aerial mycelium, composed of nodose-septate hyphae, but they may develop sectors of scanty, farinaceous mycelium made up of hyphae with simple septa, which fragment to form oidia. Cultures that have been in stock for some time and frequently subcultured are all appressed, with farinaceous surface, simple septa, and oidia. Brodie (36) in discussing the records of oidium production in the Hymenomycetes, advanced the suggestion that such oidia "are borne on uninucleate branches arising from the dicaryon mycelium". This seems to be the case in *Trametes americana* where not only do some parts of the mycelium revert to the haploid condition, recognizable by the presence of simple septa and oidia, but these sectors grow more rapidly than the nodose-septate mycelium, so that through successive transfers the nodose-septate mycelium is completely replaced by mycelium with simple septa. A similar change occurs in cultures of *Merulius lacrymans*.

Chlamydospores were observed on the submerged mycelium of all the areas with nodose-septate hyphae, but were rare or lacking in the areas composed of hyphae with simple septa. Therefore the key patterns show chlamydospores with nodose-septate hyphae, but show simple septate hyphae both with and without chlamydospores. Similarly, oidia are always found on hyphae with simple septa, but may or may not be found in a colony having clamp connections, and this correlation is shown in the key. Eight key patterns are necessary for the species, of which five stand alone in the key, the other three coinciding with the key patterns for one or more other species. Descriptive keys are provided for the separation of these groups.

Trametes americana has been considered by some authors as a form of *Lenzites saepiaria*. Snell, Hutchinson, and Newton (140) used temperature relations and Mounce and Macrae (113) used interfertility tests to establish the specific rank of each of these species. The present study has shown further marked differences in cultural characters, the most noticeable being the fragmentation of nodose-septate hyphae in *Lenzites saepiaria* to form oidia, and the restriction of oidium formation to hyphae with simple septa in *Trametes americana*.

Trametes heteromorpha (Fries) Bres.

KEY PATTERN: 2 1 2 1 9 2 2 2 3 (1, 2) 2

CULTURES EXAMINED:

CANADA.—British Columbia: Aleza Lake, on *Picea glauca*, 16620, on conifer, 16558; Blue River, on *Tsuga heterophylla*, 16094; Hidden Lake, on *T. heterophylla*, 16095; Lumby, on *Picea Engelmanni*, 8440, on *Pseudotsuga taxifolia*, 8439. UNITED STATES.—Pennsylvania: on *Tsuga* sp., 11991.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 7; Pl. XVIII, Figs. 19 to 23).

GROWTH CHARACTERS.—Growth slow, plates covered in five to six weeks. Advancing zone even, appressed, hyaline, the limit of growth usually clearly defined. Mat white, at first downy, translucent, becoming more compact, woolly, opaque, mostly appressed but frequently with a zone of raised mycelium midway across colony, usually fruiting after five to six weeks over area of newest growth remote from inoculum, the fruiting surfaces on slightly raised woolly mycelium, the pores broad with relatively thick dissepiments. Reverse unchanged. Odor slight, fruity. On gallic and tannic acid agars no diffusion zones, colony 2.0–2.5 cm. diameter on gallic acid agar, no growth or only a trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, frequently branched, 2.2–4.5μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, up to 6.0μ diameter, the broader hyphae frequently having walls irregularly thickened and refractive, and lumina narrow; (*b*) fiber hyphae numerous, aseptate, rarely branched, 2.2–3.0μ diameter, curving and interwoven. *Fruit body:* (*a*) nodose-septate and (*b*) fiber hyphae as in aerial mycelium; (*c*) basidia 6.0–7.5μ diameter, bearing four sterigmata up to 7.5μ in length; (*d*) basidiospores hyaline, even, cylindric, slightly flattened on one side, 10.8–13.5 × 3.6–4.5μ. *Submerged mycelium:* nodose-septate hyphae as in aerial mycelium.

TYPE OF ROT: brown cubical rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson, Campbell, and Blaisdell (64), Mounce (111).

The two key patterns for *Trametes heteromorpha* are identical with those for *T. serialis*, *T. sepium*, and *T. variiformis*. Descriptive keys, in which separations are based on macroscopic appearance and size of basidiospores,

have been inserted but these have not proved satisfactory. It has been found necessary, therefore, to submit isolates that have these key patterns to interfertility tests. Such a test requires the isolation of single spore cultures from the unknown culture and the pairing of these with single spore cultures from authentic fruit bodies of *Trametes heteromorpha*, *T. serialis*, and *T. variiformis*. To date it has not been possible to obtain single spore cultures from *T. sepium* and this species has not been included in the tests. To illustrate, V702 was isolated from a decay in *Tsuga heterophylla*. Its cultural characters showed it to belong to one of the species within the group. Pairings were made, and the results are shown in Text-figs. 1, 2, and 3. In these a plus (+) indicates that hyphae bearing clamp connections were formed, a minus (−) indicates that no clamp connections were found on the hyphae in the pairing. It will be

8439

V702	1	2	3	6
1	+	+	+	+
2	+	+	+	+
3	+	+	+	+
4	+	+	+	+

11983

V702	1	2	3	4
1	−	−	−	−
2	−	−	−	−
3	−	−	−	−
4	−	−	−	−

TEXT-FIG. 1. *Results obtained by pairing four monosporous mycelia from an unidentified culture, V702, with four monosporous mycelia from a fruit body of* Trametes heteromorpha, 8439.

TEXT-FIG. 2. *Results obtained by pairing four monosporous mycelia from an unidentified culture, V702, with four monosporous mycelia from a fruit body of* Trametes serialis, *11983.*

10231

V702	3	5	7	8
1	−	−	−	−
2	−	−	−	−
3	−	−	−	−
4	−	−	−	−

TEXT-FIG. 3. *Results obtained by pairing four monosporous mycelia from an unidentified culture, V702, with four monosporous mycelia from a fruit body of* Trametes variiformis, *10231.*

observed that every pairing between the unknown and *T. heteromorpha* produced mycelium bearing clamp connections, while no clamp connections were produced in the pairings between the unknown fungus and *T. serialis* and *T. variiformis*. Hence the unknown fungus is *T. heteromorpha*. Recourse must be made to interfertility tests for determinations within this group of species until a satisfactory basis of separation on cultural characters is established.

Trametes sepium Berk.

KEY PATTERN: (1,2) 1 2 1 9 2 2 2 3 (1,2) 2

CULTURES EXAMINED:

UNITED STATES.—Virginia, on *Quercus* sp., 11987, 11988, 11989. Maryland: on *Quercus* sp., 11990.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 8; Pl. XVIII, Figs. 24 to 26).

GROWTH CHARACTERS.—Growth slow, plates covered in five weeks. Advancing zone even, aerial mycelium uniform to limit of growth. Mat white, at first appressed, downy, all so thin as to be translucent, soon developing zones in which mycelium is slightly raised, woolly, opaque, the surface becoming pebbled and, after four to six weeks, pored in most isolates. Reverse unchanged. Odor faint, fruity. On gallic and tannic acid agars no diffusion zones, colonies 2.0 cm. diameter on gallic acid agar, trace of growth on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 2.2–3.7μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently up to 6.0μ diameter, with walls irregularly thickened and refractive, the lumina irregular, with contents staining in phloxine; (*b*) fiber hyphae numerous, with walls thick and refractive and lumina entirely lacking, rarely branched, curving and interwoven, 2.2–3.0μ diameter. *Submerged mycelium:* (*a*) nodose-septate hyphae as in aerial mycelium.

TYPE OF ROT: brown rot of broad-leaved or, rarely, coniferous trees.

As was stated under *Trametes heteromorpha*, no satisfactory basis for separating the similar cultures of *T. heteromorpha*, *T. serialis*, and *T. variiformis* has been found. Unlike the other species within the group, *T. sepium* has not produced basidiospores in culture although pored fruiting surfaces have developed. It has not been possible, therefore, to apply the interfertility tests for cultures of *T. sepium*. It may be that this lack of spore production in six-weeks-old cultures may permit recognition of cultures of *T. sepium*.

Trametes serialis Fries

KEY PATTERN: (1,2) 1 2 1 9 2 2 2 3 1 2

CULTURES EXAMINED:

CANADA.—Quebec: Calumet, on coniferous log, 10230; Eagle Depot, on *Picea mariana*, 9519; Gaspé County, on *Picea* sp., F6813. British Columbia: Queen Charlotte Islands, on *Picea sitchensis*, 10727, 11718. UNITED STATES.—Pennsylvania: Kane, on *Tsuga* sp., 10912. NORWAY.—Oslo, on *Picea excelsa*, F7353, on coniferous log, F7399.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 9; Pl. XVIII, Figs. 27 to 31).

GROWTH CHARACTERS.—Growth slow, plates covered in five to six weeks. Advancing zone 1.0–2.0 cm. broad, appressed, hyaline, changing abruptly to white mat, appressed, felty, soon pitted and corrugated to form irregularly pored surface (one to three weeks), which finally extends over whole surface of colony. Reverse unchanged. Odor none or slightly fruity. On gallic and tannic acid agars no diffusion zones (may be slight browning around colony on gallic acid agar), colony 1.0–2.0 cm. diameter on gallic acid agar, trace to 1.0 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, 1.5–4.5(–6.0)μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently with numerous, small, pointed projections in which walls are thickened and refractive; (*b*) fiber hyphae very numerous, walls thick and refractive, aseptate, occasionally branched, 1.5–3.0μ diameter. *Fruit body:* (*a*) thin-walled and (*b*) fiber hyphae as in aerial mycelium; (*c*) basidia 4.5–6.3μ diameter, bearing four sterigmata up to 4.5–7.2μ in length; (*d*) basidiospores hyaline, even, cylindric, (5.4–)6.3–8.1 × 2.2–2.7μ. *Submerged mycelium:* (*a*) nodose-septate hyphae as described above; (*b*) crystals numerous, octahedral or platelike.

TYPE OF ROT: brown cubical rot of broad-leaved and coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Davidson and Campbell (63), Davidson, Campbell, and Blaisdell (64), Mez (106), Nobles (117), Robak (133, 134), Walek-Czernecka (150).

The difficulty of separating the cultures of *Trametes heteromorpha*, *T. sepium*, *T. serialis*, and *T. variiformis* has been discussed under *T. heteromorpha*. The size of basidiospores of *T. serialis* is a precise diagnostic character, and this, together with the macroscopic appearance of the mats produced by this species may be sufficient to separate it from others. However, the use of interfertility tests to corroborate identifications based on cultural characters is recommended.

Trametes suaveolens (L.) Fries

KEY PATTERNS: 1 1 1 1 9 1 2 2 (1,2) 2 3

CULTURES EXAMINED:

CANADA.—Quebec: Matapedia, on *Salix* sp., F7654. Ontario: Ottawa, on *Salix* sp., F3522, F3523, F5032. Manitoba: Winnipeg, on *Salix* sp., F2350.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 10; Pl. XVIII, Figs. 32 to 34).

GROWTH CHARACTERS.—Growth rapid to moderately rapid, plates covered in two to three weeks. Advancing zone even, slightly raised aerial mycelium to limit of growth. Mat white, at first slightly raised, fine downy-floccose, becoming woolly to subfelty but with overgrowth of balls of cottony mycelium around edge of plate and scattered more or less continuously over surface. Reverse unchanged for one week, then completely bleached. Odor strong, sweet. On gallic and tannic acid agars diffusion zones strong, no growth on gallic acid agar, trace on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate, the clamp connections frequently large, 2.2–4.5μ diameter. *Aerial mycelium:* hyphae as in advancing zone, usually 1.5–3.0μ diameter; (*b*) fiber hyphae fairly numerous, rarely branched, walls thick and refractive and lumina no longer visible, 1.5–2.2μ diameter; (*c*) chlamydospores numerous, thin-walled, terminal and intercalary, long and cylindric or broadly ovoid, 7.5–15.0 × 4.5–6.0μ. *Submerged mycelium:* hyphae as in advancing zone.

TYPE OF ROT: white heart rot of *Salix* spp. and, occasionally, *Populus* spp.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3), Hirt (85), Vandendries (141).

Trametes suaveolens falls with *Polyporus versicolor* and *P. zonatus* in the key and there appears to be no definite character by which they may be separated. The preference of *Trametes suaveolens* for *Salix* spp. and the strong sweet odor of the culture, similar to that produced by sporophores of the fungus, should make possible the recognition of cultures of this species.

Trametes tenuis Karst.

KEY PATTERN: (1,2) (1,2) 1 2 9 2 2 2 4 2 2

CULTURES EXAMINED:

CANADA.—British Columbia: Cowichan Lake, on *Thuja plicata*, 8208, 8209, 8217, 9265, 9266, 9293; Yellow Point, on *T. plicata*, 8257.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 11; Pl. XVIII, Figs. 35 to 37).

GROWTH CHARACTERS.—Growth very slow, radius 5.2–7.0 cm. in six weeks. Advancing zone even or slightly bayed, aerial mycelium uniform to limit of growth. Mat white at first, after three to four weeks developing scattered or more or less continuous areas, especially around inoculum, of "cinnamon-buff" (9.0YR6.6/5.8), "clay color" (10.0YR5.8/6.0), and "ochraceous-tawny" (6.0YR4.9/6.3), appressed, farinaceous to thin felty, minutely tufted. Reverse unchanged, or with zone of blue-green color that disappears after four or five weeks. Odor strong and unpleasant. On gallic and tannic acid agars diffusion zones moderately strong to strong, trace of growth to colonies 1.2 cm. diameter on both media.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, thin-walled, with rare simple septa, 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, with occasional swellings up to 13.5μ diameter, these soon appearing devoid of contents and non-staining; (*b*) hyphae with brown walls, fairly rare, usually the ends of hyaline hyphae, with walls thick and lumina visible only in the broader ones, 1.5–3.0μ diameter. *Submerged mycelium:* hyaline hyphae as in aerial mycelium.

TYPE OF ROT: white rot of coniferous and broad-leaved trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Badcock (3).

Three of the key patterns for *Trametes tenuis* stand alone in the key, the fourth falls with the key pattern for *Fomes connatus*. The appressed, farinaceous to thin felty mats, always showing patches of color, of cultures of *Trametes tenuis* are completely unlike the white mats of *Fomes connatus*. Hence no difficulty should be experienced in distinguishing between these two species.

Trametes variiformis Peck

KEY PATTERN: 2 1 2 1 9 2 2 2 (3,4) (1,2) 2

CULTURES EXAMINED:

CANADA.—Quebec: Gaspé County, on *Picea glauca*, F8046. British Columbia: Blue River, on *Pinus monticola*, 16097, on *Tsuga heterophylla*, 16098; Clearwater, on *Abies lasiocarpa*, 16038, 16099; Prince George, on *Picea glauca*, 16572, 16573, on *Pseudotsuga taxifolia*, 16608.

CULTURAL CHARACTERS: (Pl. XVII, Fig. 12; Pl. XVIII, Figs. 38 to 42).

GROWTH CHARACTERS.—Growth slow to very slow, plates covered in six weeks or radius 6.0 cm. or more in six weeks. Advancing zone even, hyaline and appressed, with fibers far apart so that it is difficult to see limit of growth. Mat white, the newer growth appressed, downy to fine woolly, developing small dots of more compact mycelium that finally coalesce to form continuous, felty to pellicular surface over older part, which may become covered with pores after four to five weeks in some isolates. Reverse unchanged. Odor strong, unpleasant. On gallic and tannic acid agars no diffusion zones (may be slight browning below inoculum), colonies 1.0–3.0 cm. diameter on gallic acid agar, trace of growth to colonies 1.3 cm. diameter on tannic acid agar.

HYPHAL CHARACTERS.—*Advancing zone:* hyphae hyaline, nodose-septate 1.5–3.0μ diameter. *Aerial mycelium:* (*a*) hyphae as in advancing zone, frequently with walls irregularly thickened and refractive, or with small projections along walls or clamp connections so thickened; (*b*) fiber hyphae numerous, with walls thick and refractive and lumina apparently lacking, occasionally branched, interwoven to form tough pellicle, 2.2–3.0μ diameter. *Fruit body:* (*a*) basidia scattered or in continuous hymenium, 6.0–9.0μ diameter, bearing four spores; (*b*) basidiospores hyaline, even, cylindric, apiculate, 7.2–9.0 × 2.7–3.6 μ. *Submerged mycelium:* (*a*) nodose-septate hyphae as in aerial mycelium; (*b*) crystals large, octahedral, or small, platelike.

TYPE OF ROT: light brown cubical rot of coniferous trees.

DESCRIPTIONS OF CULTURAL CHARACTERS: Mounce (111).

Only one of the four key patterns for *Trametes variiformis* falls alone in the key. One coincides with the key pattern for *Polyporus fragilis*, cultures of which have thin, translucent mats lacking fiber hyphae, quite unlike cultures of *Trametes variiformis*, which have felty mats consisting mainly of fiber hyphae. The two remaining key patterns fall in the group including *T. heteromorpha*, *T. sepium*, and *T. serialis*. The remarks on separations within the group under *T. heteromorpha* are equally applicable to *T. variiformis*.

Discussion

Following each field season in recent years several hundred cultures of wood-rotting fungi have been identified with the aid of the foregoing key. The majority of these cultures were isolated by Dr. J. E. Bier, formerly of the Dominion Laboratory of Forest Pathology, Victoria, and his associates, in the course of their studies of decay in various species of British Columbia trees. Early in their investigations the difficulty of determining the causal organisms by direct examination of the rots was recognized and "cultures were prepared from all decays that could not be determined positively in the field". These were submitted to the author for identification.

In most projects a large percentage of the cultures, usually about 80%, are readily identifiable but the remaining isolates frequently defy identification. These may be unusual forms of species included in the key but more often belong to species not represented there or in the stock culture collection. Identification must be delayed until named cultures showing identical characters are obtained from fruit bodies. Some of the cultures that proved difficult to determine have been found to belong to undescribed species. Thus *Lentinus Kauffmanii*, of which cultures were obtained from decay in 1925, was described and named only in 1946 (Bier and Nobles (30)). Other cultures, such as *Omphalia campanella* and *Trechispora raduloides*, remained unidentified until linked with cultures from species previously listed as saprophytes and not suspected of causing decay in living trees. Meanwhile the steadily growing accumulation of unidentified cultures from rots, stresses the necessity for continuous research. Mycological studies, involving the collection and identification of sporophores from the hosts and localities under consideration, and the isolation and description of cultures from them should precede or accompany pathological studies. Only by this means can comprehensive information with regard to the fungi that cause decay be accumulated.

The identification of the majority of the cultures submitted has provided precise data on the species of fungi responsible for decay in the hosts under consideration. This information has been incorporated in a number of publications from the Victoria Laboratory, such as *Decay of Sitka Spruce on the Queen Charlotte Islands*, by Bier, Foster, and Salisbury (29).

These authors reported that "This work demonstrated that overmature Sitka spruce is attacked by many wood-destroying fungi", and supported their

statement with a list of 31 species found causing decay in living Sitka spruce on the Queen Charlotte Islands. Similarly Davidson, Campbell, and Vaughn (67) in their publication *Fungi Causing Decay of Living Oaks in the Eastern United States and Their Cultural Identification* stated "As a result of these studies a number of fungi that were not previously known to cause important heart rot in oaks were obtained", and listed 47 species that had been found to produce decay in that host. Other authors have reported similar observations. Thus the result of the application of the cultural method to decay studies has been to increase the number of species known to be of pathological significance in the various hosts and to emphasize the complex nature of the decay problem. It would appear that the method must be adopted whenever precise information on the causes of decay in a given host is required.

Acknowledgments

Methods, information on cultures, and terminology have been freely borrowed from many publications, and while individual acknowledgments cannot be made, the writer expresses her great indebtedness to the authors of all of these. Special thanks are due to Dr. Irene Mounce (Mrs. Gordon Stewart) who initiated the project, to Dr. J. H. Craigie, Dominion Botanist, and Mr. A. W. McCallum, Forest Pathologist, Division of Botany and Plant Pathology, for their sustained interest in the problem and for critical reading of parts of the manuscript, to Mr. R. W. Davidson of the Division of Forest Pathology, Bureau of Plant Industry, United States Department of Agriculture, for cultures and helpful suggestions, and to the many individuals who have assisted by identifying specimens and contributing cultures and specimens. The Munsell equivalents for the Ridgway color terms were determined by Dr. D. H. Hamly and Mr. W. I. Illman of the Department of Botany, University of Toronto, whose generous assistance was greatly appreciated.

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PLATE I

FIGS. 1 TO 15. *Cultures grown on malt agar in the dark.*

FIG. 1. Armillaria mellea, *8559, six weeks old.*
FIG. 2. Collybia radicata, *F3461, six weeks old.*
FIG. 3. Collybia velutipes, *F1598, four weeks old.*
FIG. 4. Coniophora puteana, *8547, two weeks old.*
FIG. 5. Daedalea confragosa, *9210, two weeks old.*
FIG. 6. Daedalea quercina, *F2158, five weeks old.*
FIG. 7. Daedalea unicolor, *F8022, three weeks old.*
FIG. 8. Echinodontium tinctorium, *F1157, four weeks old.*
FIG. 9. Favolus alveolaris, *F1338, four weeks old.*
FIG. 10. Fomes annosus, *8429, four weeks old.*
FIG. 11. Fomes conchatus, *9219, four weeks old.*
FIG. 12. Fomes connatus, *F7990, four weeks old.*
FIG. 13. Fomes Ellisianus, *F7520, four weeks old.*
FIG. 14. Fomes Everhartii, *F3580, four weeks old.*
FIG. 15. Fomes fomentarius, *9214, four weeks old.*

PLATE I

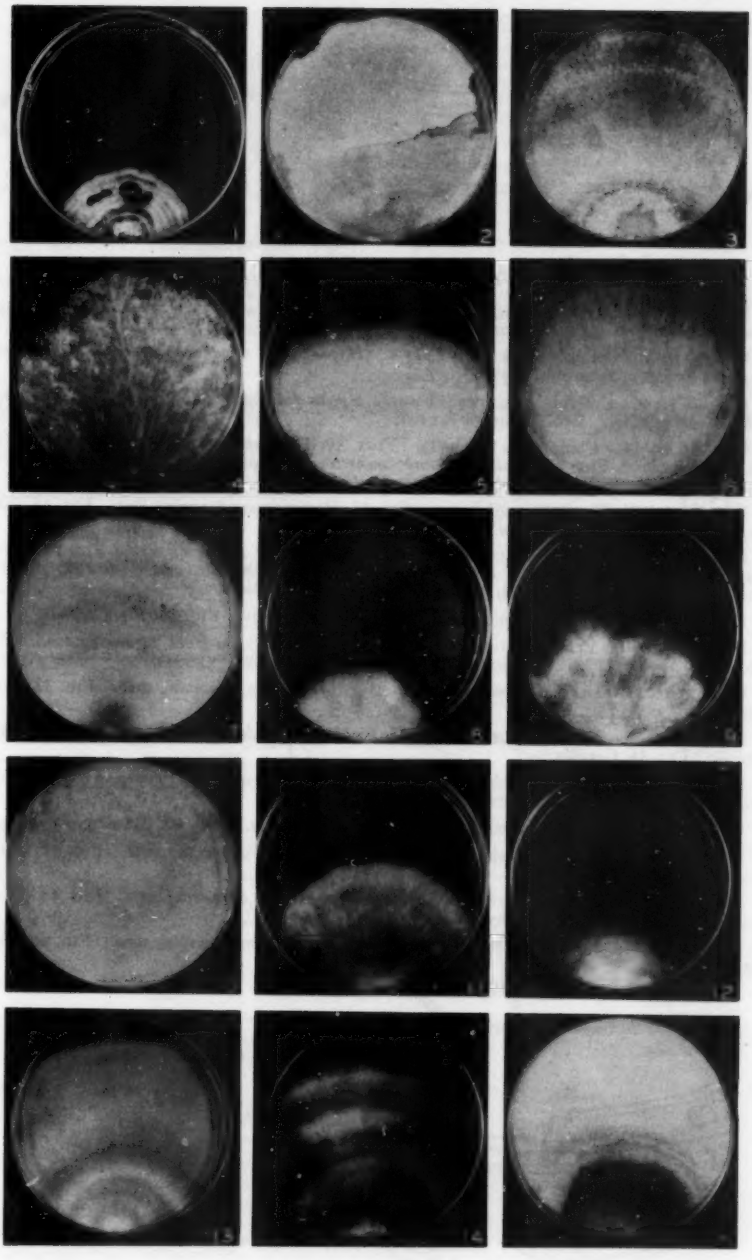

PLATE II

FIGS. 1 TO 48. *All* ×455.

FIGS. 1 TO 3. Armillaria mellea. FIG. 1. *Hypha from advancing zone.* FIG. 2. *Rough-walled aerial hypha.* FIG. 3. *Cuticular cells.*

FIGS. 4 TO 6. Collybia radicata. FIG. 4. *Hypha from advancing zone.* FIG. 5. *Aerial hypha.* FIG. 6. *Submerged hypha.*

FIGS. 7 TO 9. Collybia velutipes. FIG. 7. *Hypha from advancing zone.* FIG. 8. *Aerial hypha bearing oidia.* FIG. 9. *Lactiferous cell.*

FIGS. 10 TO 14. Coniophora cerebella. FIGS. 10, 11. *Hyphae from advancing zone.* FIG. 10. *Hyphal tips.* FIG. 11. *Multiple clamp connections.* FIG. 12. *Rough-walled brown aerial hypha.* FIG. 13. *Hyaline aerial hypha.* FIG. 14. *Oidia.*

FIGS. 15 TO 17. Daedalea confragosa. FIG. 15. *Hypha from advancing zone.* FIG. 16. *Fiber hypha.* FIG. 17. *Much-branched hyphae from skinlike layer.*

FIGS. 18 TO 24. Daedalea quercina. FIG. 18. *Hypha from advancing zone.* FIG. 19. *Thick-walled aerial hypha.* FIG. 20. *Fiber hypha.* FIG. 21. *Chlamydospores.* FIG. 22. *Basidia.* FIG. 23. *Basidiospores.* FIG. 24. *Hypha from submerged mycelium.*

FIGS. 25 TO 26. Daedalea unicolor. FIG. 25. *Aerial hyphae.* FIG. 26. *Fiber hyphae.*

FIGS. 27 TO 30. Echinodontium tinctorium. FIG. 27. *Hypha from advancing zone.* FIG. 28. *Aerial hypha.* FIG. 29. *Chlamydospores.* FIG. 30. *Cystidia.*

FIGS. 31 TO 32. Favolus alveolaris. FIG. 31. *Hypha from advancing zone.* FIG. 32. *Fiber hypha.*

FIGS. 33 TO 35. Fomes annosus. FIG. 33. *Hyphae from advancing zone.* FIG. 34. *Conidiophores.* FIG. 35. *Conidia.*

FIGS. 36 TO 38. Fomes conchatus. FIG. 36. *Hypha from advancing zone.* FIG. 37. *Partly colored aerial hypha.* FIG. 38. *Submerged hyphae.*

FIGS. 39 TO 40. Fomes connatus. FIG. 39. *Aerial hyphae.* FIG. 40. *Submerged hyphae.*

FIGS. 41 TO 43. Fomes Ellisianus. FIG. 41. *Hypha from advancing zone.* FIG. 42. *Aerial hypha.* FIG. 43. *Fiber hypha.*

FIGS. 44 TO 46. Fomes Everhartii. FIG. 44. *Hypha from advancing zone.* FIG. 45. *Aerial hyphae.* FIG. 46. *Brown aerial hypha.*

FIGS. 47 TO 48. Fomes fomentarius. FIG. 47. *Hyphae from advancing zone.* FIG. 48. *Fiber hyphae.*

PLATE II

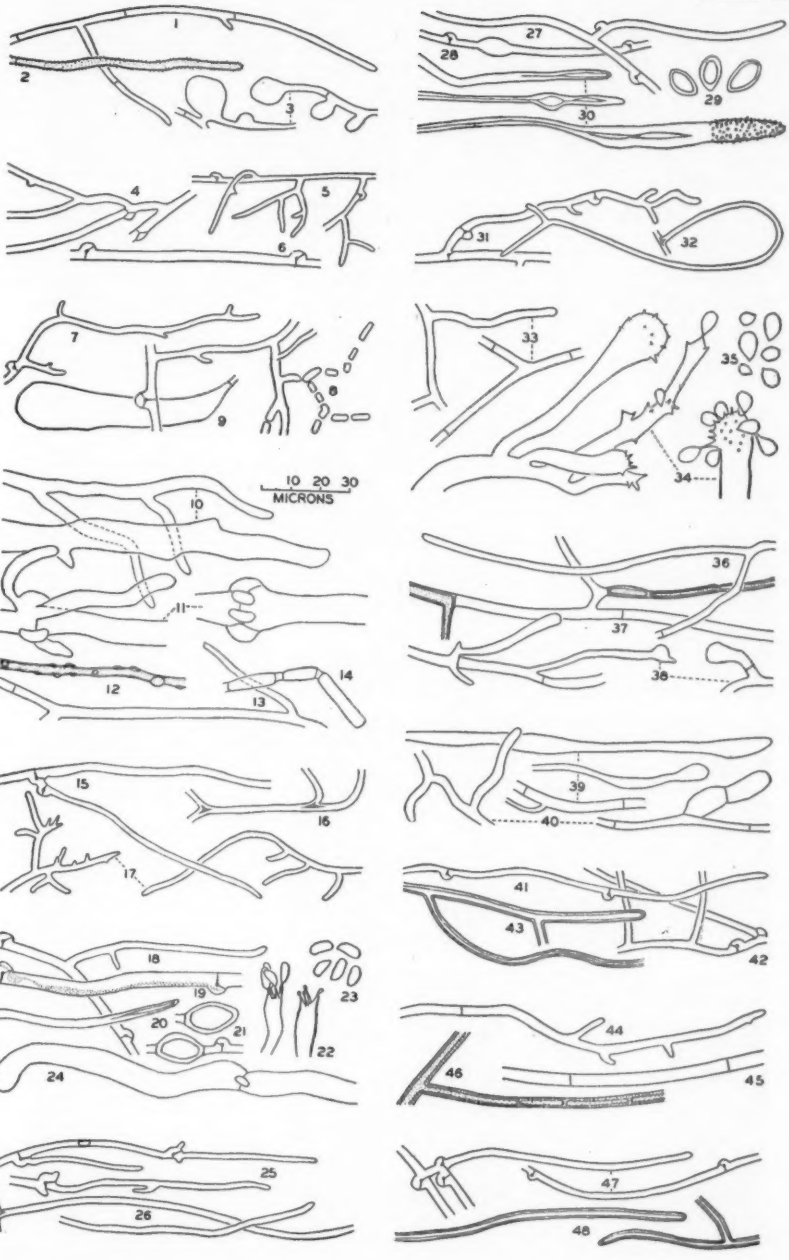
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PLATE III

FIGS. 1 TO 15. *Cultures grown on malt agar in the dark.*

FIG. 1. Fomes fraxineus, *F7519, four weeks old.*
FIG. 2. Fomes fraxinophilus, *F1932, four weeks old.*
FIG. 3. Fomes fulvus, *F2283, four weeks old.*
FIG. 4. Fomes igniarius, *F7974, four weeks old.*
FIG. 5. Fomes igniarius *var.* laevigatus, *9008, four weeks old.*
FIG. 6. Fomes igniarius *var.* populinus, *R4464, four weeks old.*
FIG. 7. Fomes nigrolimitatus, *9159, six weeks old.*
FIG. 8. Fomes officinalis, *9503, six weeks old.*
FIG. 9. Fomes ohiensis, *F8005, six weeks old.*
FIG. 10. Fomes Pini, *F2366, six weeks old.*
FIG. 11. Fomes pinicola, *9033, four weeks old.*
FIG. 12. Fomes rimosus, *F2165, six weeks old.*
FIG. 13. Fomes roseus, *F1449, four weeks old.*
FIG. 14. Fomes scutellatus, *F3444, four weeks old.*
FIG. 15. Fomes subroseus, *8184, four weeks old.*

PLATE III

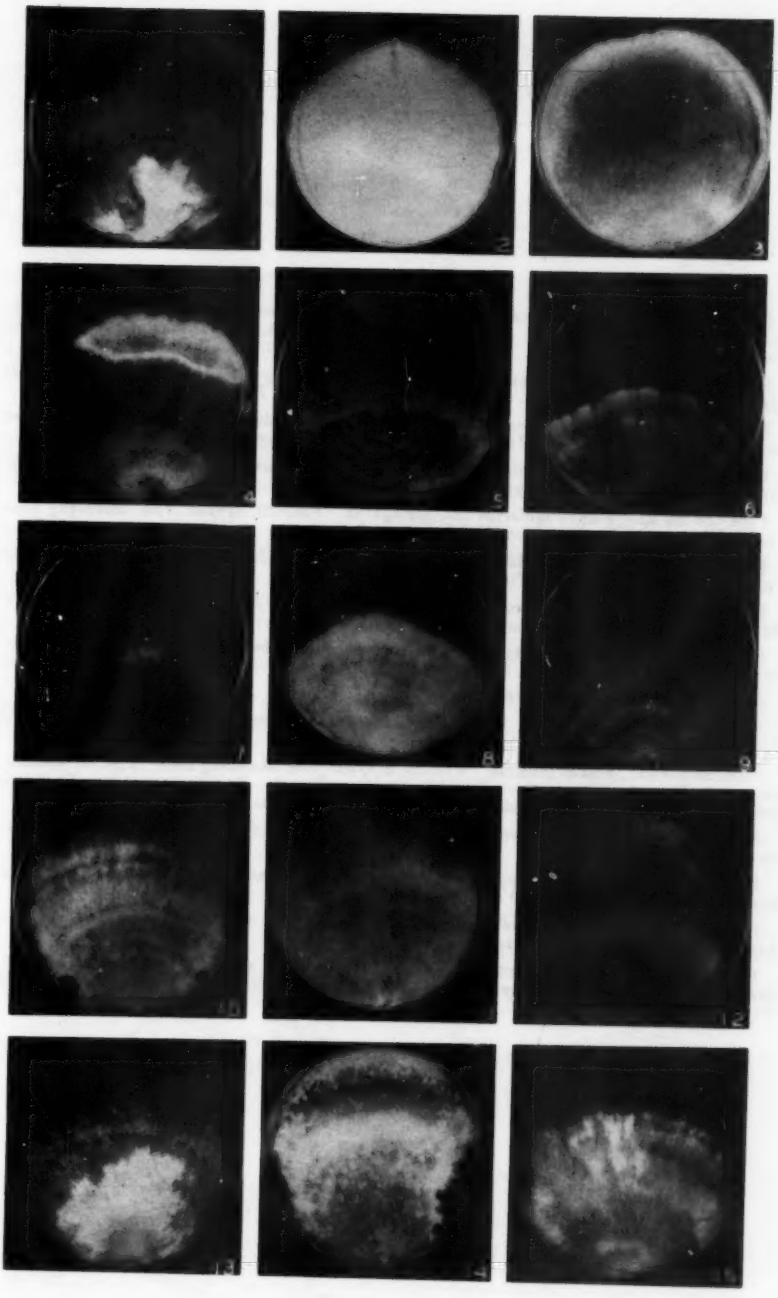

PLATE IV

FIGS. 1 TO 58. *All* ×455.

FIGS. 1 TO 6. Fomes fraxineus. FIG. 1. *Hypha from advancing zone.* FIG. 2. *Fiber hypha.* FIG. 3. *Chlamydospores.* FIG. 4. *Staghorn-branched hypha.* FIG. 5. *Basidia.* FIG. 6. *Basidiospores.*

FIGS. 7 TO 11. Fomes fraxinophilus. FIG. 7. *Hyphae from advancing zone.* FIG. 8. *Fiber hypha.* FIG. 9. *Chlamydospores.* FIG. 10. *Basidia.* FIG. 11. *Basidiospores.*

FIGS. 12 TO 15. Fomes fulvus. FIG. 12. *Hyphae from advancing zone.* FIG. 13. *Brown aerial hyphae.* FIG. 14. *Helicoid aerial hypha.* FIG. 12. *Submerged hypha.*

FIGS. 16 TO 19. Fomes igniarius. FIG. 16. *Hyphae from advancing zone.* FIG. 17. *Pale aerial hypha.* FIG. 18. *Brown aerial hypha.* FIG. 19. *Cuticular cells.*

FIGS. 20 TO 22. Fomes igniarius *var.* laevigatus. FIG. 20. *Hypha from advancing zone.* FIG. 21. *Brown aerial hypha.* FIG. 22. *Cuticular cells.*

FIGS. 23 TO 25. Fomes igniarius *var.* populinus. FIG. 23. *Hyphae from advancing zone.* FIG. 24. *Brown aerial hypha.* FIG. 25. *Cuticular cells.*

FIGS. 26 TO 29. Fomes nigrolimitatus. FIG. 26. *Hyphae from advancing zone.* FIG. 27. *Aerial hypha.* FIG. 28. *Brown aerial hypha.* FIG. 29. *Bulbils.*

FIGS. 30 TO 33. Fomes officinalis. FIG. 30. *Hypha from advancing zone.* FIG. 31. *Conidiophores.* FIG. 32. *Conidia.* FIG. 33. *Chlamydospores.*

FIG. 34. Fomes ohiensis. FIG. 34. *Hyphae.*

FIGS. 35 TO 38. Fomes Pini. FIG. 35. *Hyphae from advancing zone.* FIG. 36. *Aerial hyphae.* FIG. 37. *Aerial hyphae showing expansions.* FIG. 38. *Setae.*

FIGS. 39 TO 43. Fomes pinicola. FIG. 39. *Hyphae from advancing zone.* FIG. 40. *Chlamydospores.* FIG. 41. *Fiber hypha.* FIG. 42. *Basidia.* FIG. 43. *Basidiospores (from fruit body produced in culture on elm wood block on prune agar, four months old).*

FIGS. 44 TO 45. Fomes rimosus. FIG. 44. *Hyphae from advancing zone.* FIG. 45. *Brown aerial hyphae.*

FIGS. 46 to 49. Fomes roseus. FIG. 46. *Hypha from advancing zone.* FIG. 47. *Fiber hypha.* FIG. 48. *Basidia.* FIG. 49. *Basidiospores.*

FIGS. 50 TO 52. Fomes scutellatus. FIG. 50. *Hypha from advancing zone.* FIG. 51. *Fiber hypha.* FIG. 52. *Submerged hypha.*

FIGS. 53 TO 58. Fomes subroseus. FIG. 53. *Hypha from advancing zone.* FIG. 54. *Fiber hypha.* FIG. 55. *Broad aerial hypha.* FIG. 56. *Chlamydospores.* FIG. 57. *Basidia.* FIG. 58. *Basidiospores.*

PLATE IV

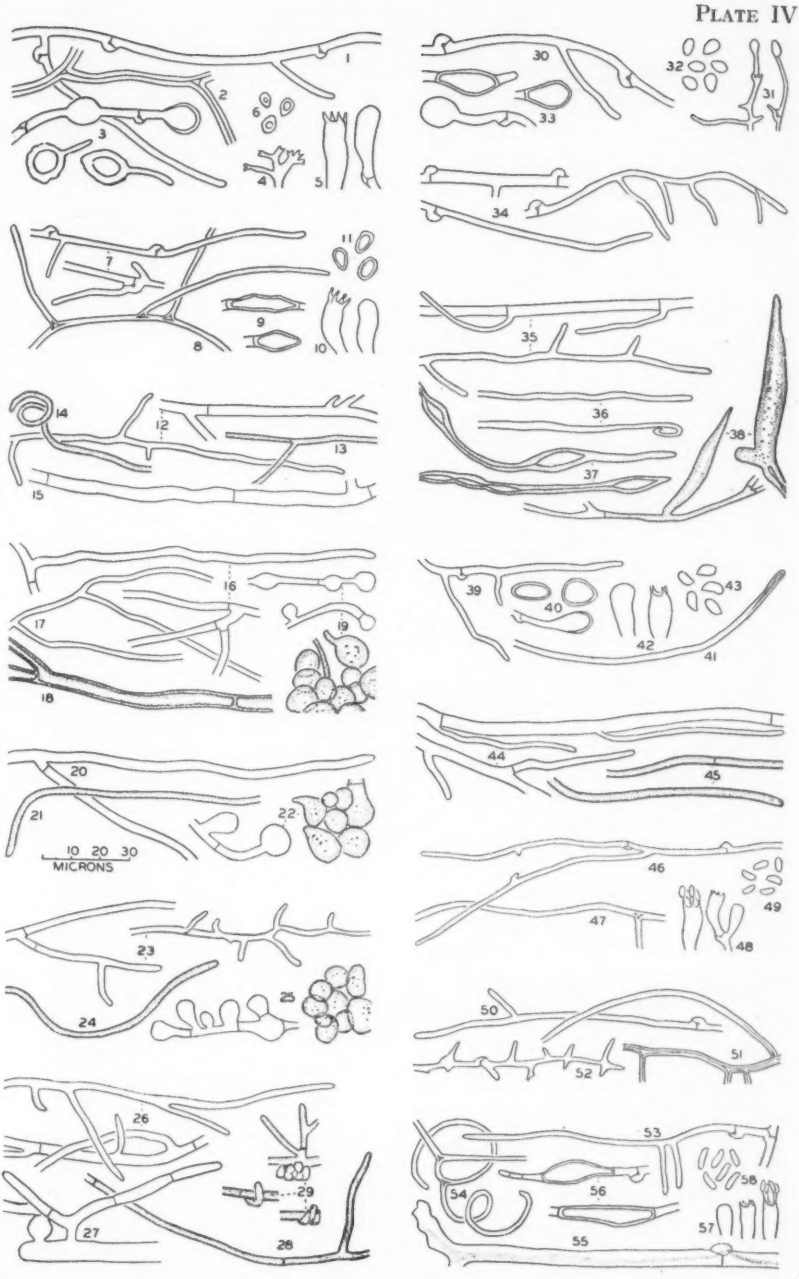
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PLATE V

FIGS. 1 TO 15. *Cultures grown on malt agar in the dark.*

FIG. 1. Ganoderma applanatum, *8180, six weeks old.*
FIG. 2. Ganoderma lobatum, *F8006, four weeks old.*
FIG. 3. Ganoderma lucidum, *10222, six weeks old.*
FIG. 4. Ganoderma oregonense, *F1274, six weeks old.*
FIG. 5. Ganoderma Tsugae, *9346, four weeks old.*
FIG. 6. Hymenochaete corrugata, *F2940, four weeks old.*
FIG. 7. Hymenochaete tabacina, *9290, four weeks old.*
FIG. 8. Lentinus Kauffmanii, *10723, six weeks old.*
FIG. 9. Lentinus lepideus, *F627, four weeks old.*
FIG. 10. Lentinus tigrinus, *F3048, four weeks old.*
FIG. 11. Lenzites betulina, *10199, four weeks old.*
FIG. 12. Lenzites saepiaria, *9419, six weeks old.*
FIG. 13. Lenzites trabea, *F3823, four weeks old.*
FIG. 14. Merulius lacrymans, *8787, five weeks old.*
FIG. 15. Merulius lacrymans, *same isolate as Fig. 14, after reverting to the haploid condition, six weeks old.*

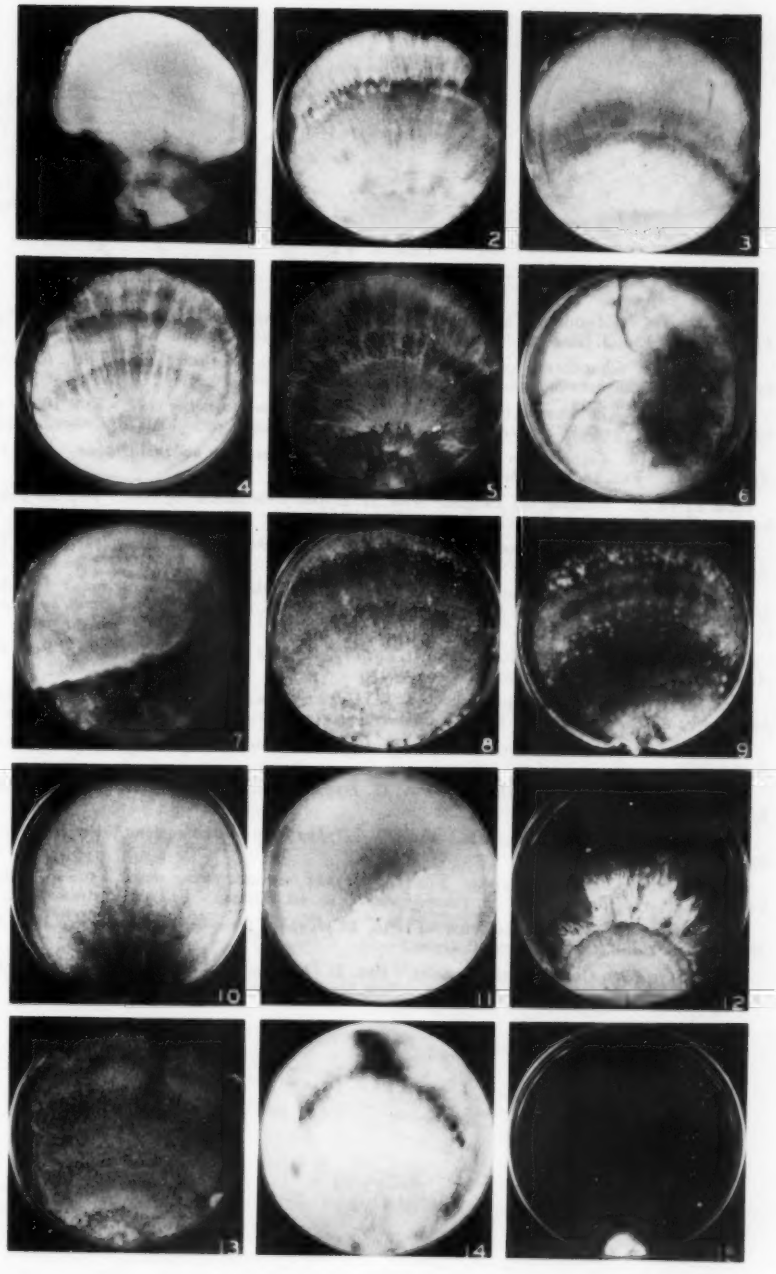
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PLATE VI

FIGS. 1 TO 53. *All* ×455.

FIGS. 1 TO 4. Ganoderma applanatum. FIG. 1. *Hyphae from advancing zone.* FIG. 2. *Fiber hypha.* FIG. 3. *Staghorn-branched hypha.* FIG. 4. *Cuticular cells.*

FIGS. 5 TO 8. Ganoderma lobatum. FIG. 5. *Hypha from advancing zone.* FIG. 6. *Fiber hypha.* FIG. 7. *Staghorn-branched hypha.* FIG. 8. *Cuticular cells.*

FIGS. 9 TO 13. Ganoderma lucidum. FIG. 9. *Hypha from advancing zone.* FIG. 10. *Fiber hypha.* FIG. 11. *Staghorn-branched hypha.* FIG. 12. *Chlamydospores.* FIG. 13. *Cuticular cells.*

FIGS. 14 TO 16. Ganoderma oregonense. FIG. 14. *Hypha from advancing zone.* FIG. 15. *Aerial hypha.* FIG. 16. *Cuticular cells.*

FIGS. 17 TO 20. Ganoderma Tsugae. FIG. 17. *Hypha from advancing zone.* FIG. 18. *Fiber hypha.* FIG. 19. *Staghorn-branched hypha.* FIG. 20. *Cuticular cells.*

FIGS. 21 TO 22. Hymenochaete corrugata. FIG. 21. *Hypha from advancing zone.* FIG. 22. *Aerial hypha.*

FIGS. 23 to 26. Hymenochaete tabacina. FIG. 23. *Hypha from advancing zone.* FIG. 24. *Hyaline aerial hypha.* FIG. 25. *Brown aerial hypha.* FIG. 26. *Cells from pseudoparenchymatous layer.*

FIGS. 27 TO 29. Lentinus Kauffmanii. FIG. 27. *Hyphae from advancing zone.* FIG. 28. *Aerial hypha.* FIG. 29. *Fiber hypha.*

FIGS. 30 TO 34. Lentinus lepideus. FIG. 30. *Hyphae from advancing zone.* FIG. 31. *Aerial hypha.* FIG. 32. *Fiber hypha.* FIG. 33. *Chlamydospores.* FIG. 34. *Swollen submerged hypha.*

FIGS. 35 TO 36. Lentinus tigrinus. FIG. 35. *Hyphae from advancing zone.* FIG. 36. *Chlamydospores.*

FIGS. 37 TO 38. Lenzites betulina. FIG. 37. *Hyphae from advancing zone.* FIG. 38. *Fiber hypha.*

FIGS. 39 TO 41. Lenzites saepiaria. FIG. 39. *Hypha from advancing zone.* FIG. 40. *Aerial hypha.* FIG. 41. *Oidia.*

FIGS. 42 TO 47. Lenzites trabea. FIG. 42. *Hypha from advancing zone.* FIG. 43. *Oidia.* FIG. 44. *Chlamydospores.* FIG. 45. *Fiber hypha.* FIG. 46. *Basidia.* FIG. 47. *Basidiospores.*

FIGS. 48 TO 50. Merulius lacrymans. FIG. 48. *Hyphae from aerial mycelium.* FIG. 49. *Hypha from 'oidial strain'.* FIG. 50. *Oidia.*

FIGS. 51 TO 53. Omphalia campanella. FIG. 51. *Hyphae from advancing zone.* FIG. 52. *Hyphae from pseudoparenchymatous layer.* FIG. 53. *Brown hypha showing swelling.*

PLATE VI

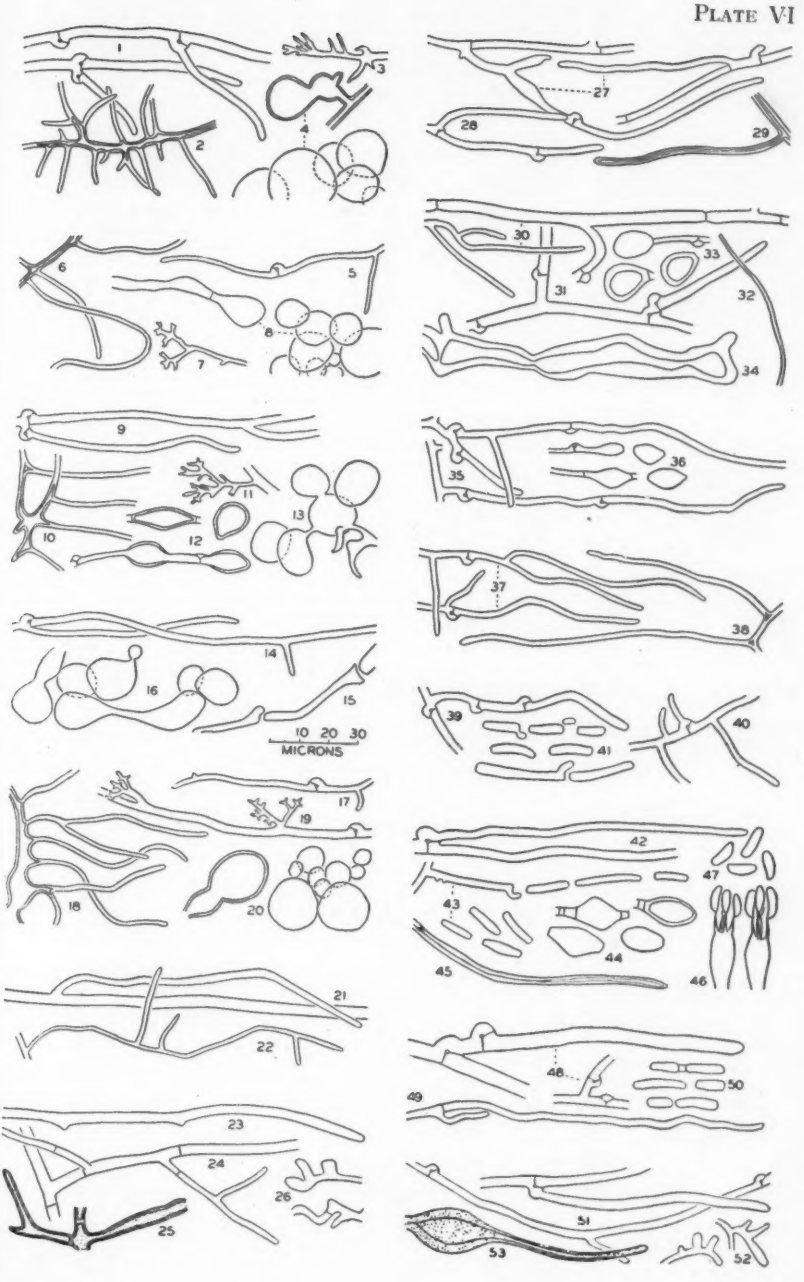
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PLATE VII

FIGS. 1 to 15. *Cultures grown on malt agar in the dark.*

FIG. 1. Omphalia campanella, *11977, six weeks old.*
FIG. 2. Peniophora gigantea, *10249, two weeks old.*
FIG. 3. Pholiota adiposa, *8457, four weeks old.*
FIG. 4. Pleurotus ostreatus, *F2949, four weeks old.*
FIG. 5. Pleurotus ulmarius, *F326, four weeks old.*
FIG. 6. Polyporus abietinus, *F7379, six weeks old.*
FIG. 7. Polyporus adustus, *11810, two weeks old.*
FIG. 8. Polyporus albellus, *F7532, two weeks old.*
FIG. 9. Polyporus amorphus, *8552, six weeks old.*
FIG. 10. Polyporus anceps, *8264, two weeks old.*
FIG. 11. Polyporus arcularius, *10447, four weeks old.*
FIG. 12. Polyporus balsameus, *F936, six weeks old.*
FIG. 13. Polyporus Berkeleyi, *F2952, four weeks old.*
FIG. 14. Polyporus betulinus, *9339, six weeks old.*
FIG. 15. Polyporus borealis, *11685, four weeks old.*

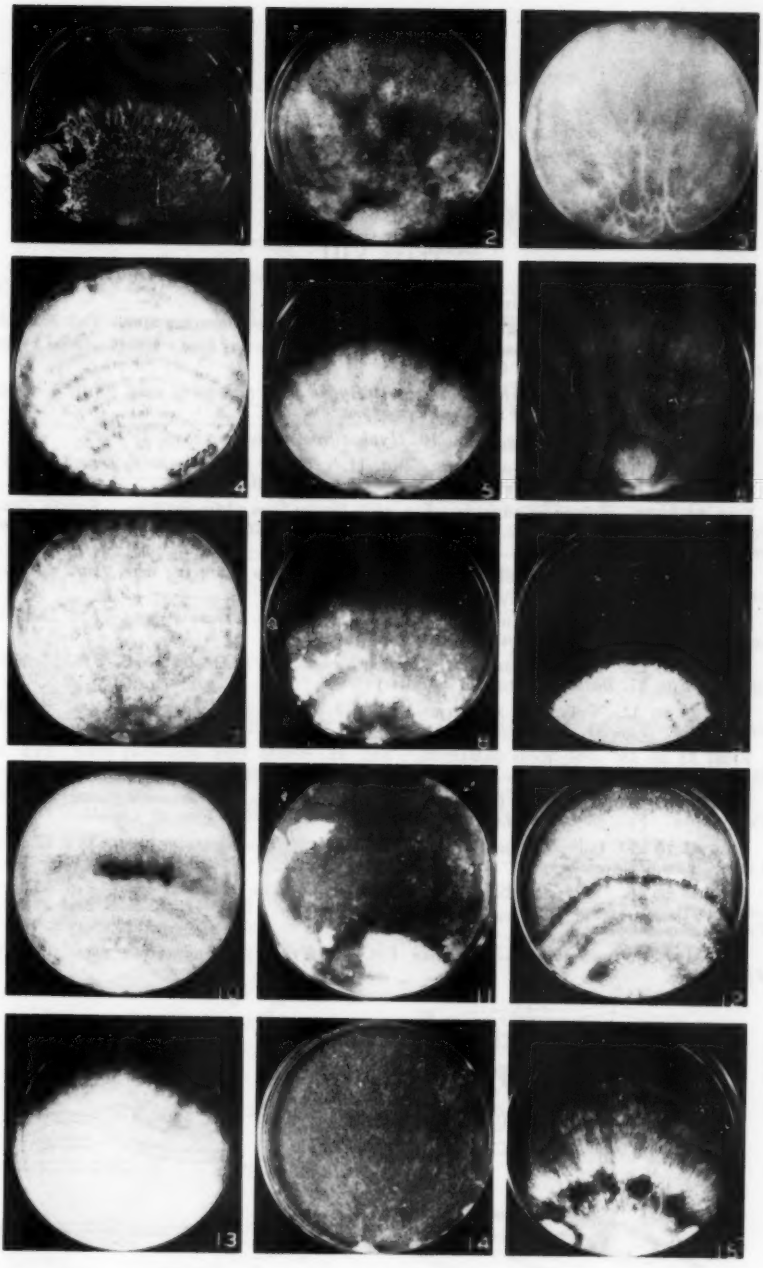
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PLATE VIII

FIGS. 1 TO 50. *All ×455.*

FIGS. 1 TO 2. Peniophora gigantea. FIG. 1. *Hyphae from advancing zone.* FIG. 2. *Oidia.*

FIGS. 3 TO 6. Pholiota adiposa. FIG. 3. *Hyphae from advancing zone.* FIG. 4. *Aerial hypha.* FIG. 5. *Conidiophores.* FIG. 6. *Conidia.*

FIGS. 7 TO 9. Pleurotus ostreatus. FIG. 7. *Hypha from advancing zone.* FIG. 8. *Aerial hyphae and hyphal segments.* FIG. 9. *Fiber hypha.*

FIG. 10. Pleurotus ulmarius. FIG. 10. *Hyphae from advancing zone.*

FIGS. 11 to 14. Polyporus abietinus. FIG. 11. *Hyphae from advancing zone.* FIG. 12. *Aerial hypha.* FIG. 13. *Fiber hypha.* FIG. 14. *Capitate incrusted cystidia.*

FIGS. 15 TO 18. Polyporus adustus. FIG. 15. *Hypha from advancing zone.* FIG. 16. *Oidia from nodose-septate hypha.* FIG. 17. *Oidiophore with simple septa.* FIG. 18. *Oidia from hypha with simple septa.*

FIGS. 19 TO 21. Polyporus albellus. FIG. 19. *Hypha from advancing zone.* FIG. 20. *Contorted incrusted hyphal tips.* FIG. 21. *Chlamydospores.*

FIGS. 22 TO 24. Polyporus amorphus. FIG. 22. *Hypha from advancing zone.* FIG. 23. *Fiber hypha.* FIG. 24. *Swellings on submerged hyphae.*

FIGS. 25 TO 28. Polyporus anceps. FIG. 25. *Hypha from advancing zone.* FIG. 26. *Fiber hyphae.* FIG. 27. *Basidia.* FIG. 28. *Basidiospores.*

FIGS. 29 TO 32. Polyporus arcularius. FIG. 29. *Hypha from advancing zone.* FIG. 30. *Fiber hypha.* FIG. 31. *Hyphae from skinlike layer.* FIG. 32. *Chlamydospores.*

FIGS. 33 TO 35. Polyporus balsameus. FIG. 33. *Hypha from advancing zone.* FIG. 34. *Hyphae bearing chlamydospores.* FIG. 35. *Mature brown chlamydospores.*

FIGS. 36 TO 39. Polyporus Berkeleyi. FIG. 36. *Hyphae from advancing zone.* FIG. 37. *Fiber hypha.* FIG. 38. *Chlamydospores.* FIG. 39. *Conidiophores.* FIG. 40. *Conidia.*

FIGS. 41 TO 43. Polyporus betulinus. FIG. 41. *Hypha from advancing zone.* FIG. 42. *Fiber hypha.* FIG. 43. *Aerial hypha.*

FIGS. 44 TO 48. Polyporus borealis. FIG. 44. *Hypha from advancing zone.* FIG. 45. *Contorted incrusted hyphal tips.* FIG. 46. *Chlamydospores.* FIG. 47. *Basidia and cystidia.* FIG. 48. *Basidiospores.*

FIGS. 49 TO 50. Polyporus brumalis. FIG. 49. *Hypha from advancing zone.* FIG. 50. *Fiber hypha.*

PLATE VIII

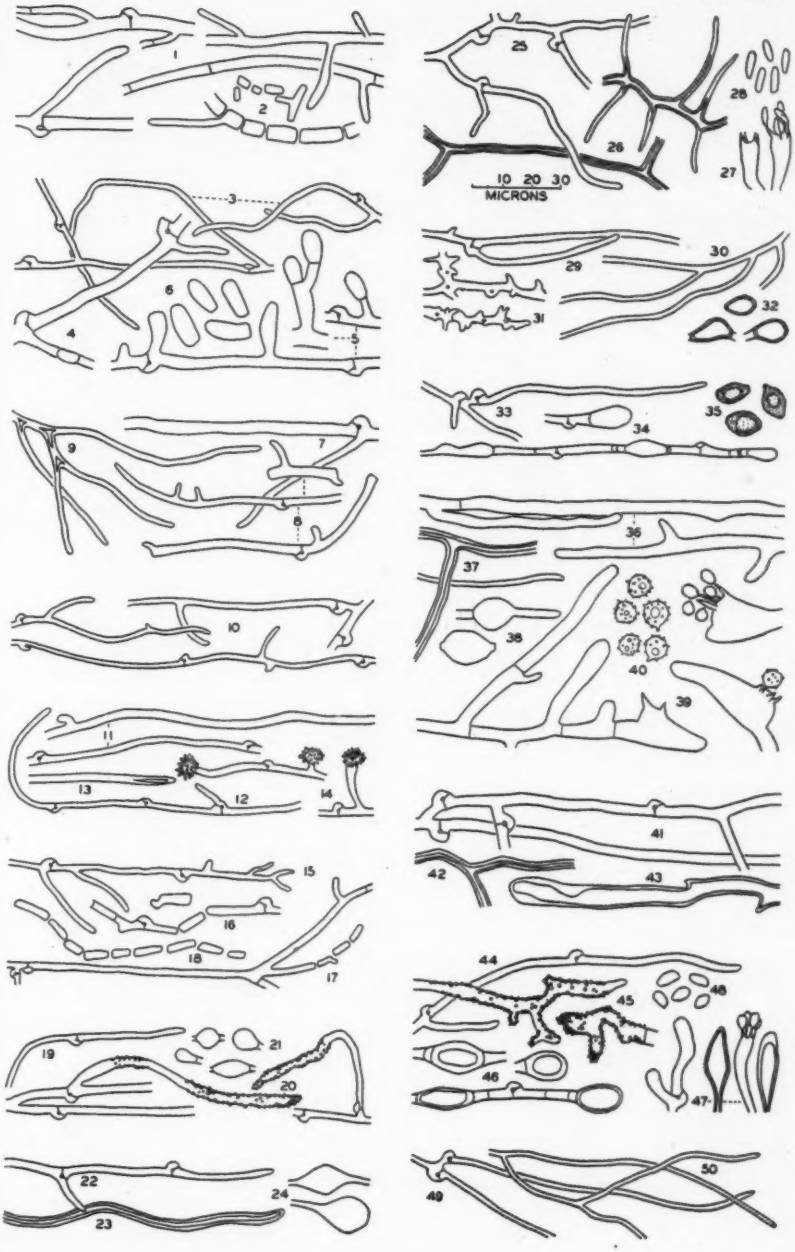
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PLATE IX

FIGS. 1 TO 15. *Cultures grown on malt agar in the dark.*

FIG. 1. Polyporus brumalis, *F1608, five weeks old.*
FIG. 2. Polyporus cinnabarinus, *F1609, four weeks old.*
FIG. 3. Polyporus circinatus, *9416, six weeks old.*
FIG. 4. Polyporus compactus, *F637, two weeks old.*
FIG. 5. Polyporus conchifer, *9343, four weeks old.*
FIG. 6. Polyporus cuticularis, *F1969, six weeks old.*
FIG. 7. Polyporus dichrous, *8287, four weeks old.*
FIG. 8. Polyporus distortus, *F7992, four weeks old.*
FIG. 9. Polyporus dryadeus, *8101, six weeks old.*
FIG. 10. Polyporus dryophilus, *F2035, four weeks old.*
FIG. 11. Polyporus dryophilus *var.* vulpinus, *F4394, four weeks old.*
FIG. 12. Polyporus fibrillosus, *8238, four weeks old.*
FIG. 13. Polyporus fragilis, *10227, six weeks old.*
FIG. 14. Polyporus frondosus, *10235, two weeks old.*
FIG. 15. Polyporus fumosus, *10257, four weeks old.*

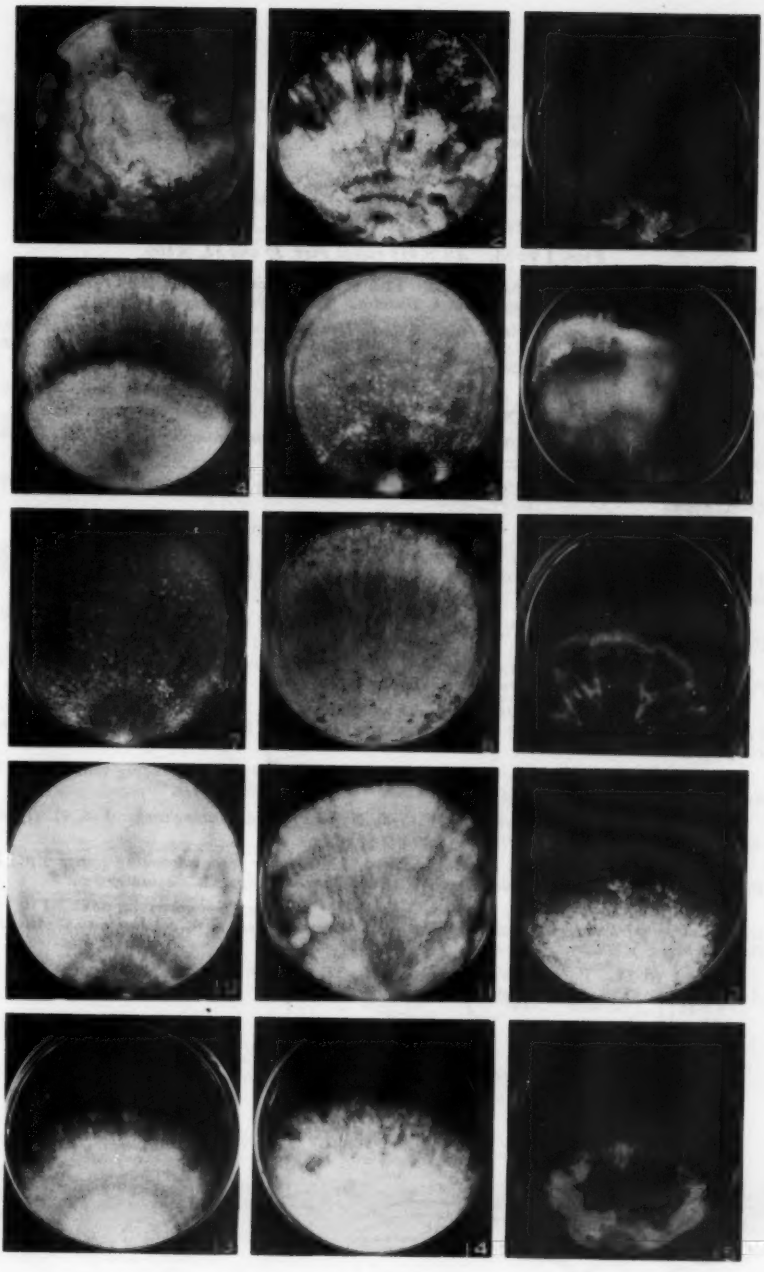

PLATE X

FIGS. 1 TO 54. *All ×455 except Figs. 36 and 51, ×800.*

FIGS. 1 TO 5. Polyporus cinnabarinus. FIG. 1. *Hypha from advancing zone.* FIG. 2. *Fiber hypha.* FIG. 3. *Chlamydospores.* FIG. 4. *Basidia.* FIG. 5. *Basidiospores.*

FIGS. 6 TO 10. Polyporus circinatus. FIG. 6. *Hyphae from advancing zone.* FIG. 7. *Dark brown aerial hyphae.* FIG. 8. *Swellings on aerial hyphae.* FIG. 9. *Hypha bearing chlamydosporelike structures.* FIG. 10. *Setae.*

FIGS. 11 TO 15. Polyporus compactus. FIG. 11. *Hyphae from advancing zone.* FIG. 12. *Fiber hyphae.* FIG. 13. *Chlamydospores.* FIG. 14. *Basidia.* FIG. 15. *Basidiospores.*

FIGS. 16 TO 17. Polyporus conchifer. FIG. 16. *Hyphae from advancing zone.* FIG. 17. *Fiber hypha.*

FIGS. 18 TO 19. Polyporus cuticularis. FIG. 18. *Hyphae from advancing zone.* FIG. 19. *Aerial hypha.*

FIG. 20. Polyporus dichrous. FIG. 20. *Hyphae from advancing zone.*

FIGS. 21 TO 25. Polyporus distortus. FIG. 21. *Hyphae from advancing zone.* FIG. 22. *Aerial hypha with chlamydospores.* FIG. 23. *Chlamydospores.* FIG. 24. *Clavate bodies.* FIG. 25. *Basidiospores, ×800.*

FIGS. 26 TO 27. Polyporus dryadeus. FIG. 26. *Hyphae from advancing zone.* FIG. 27. *Hyphae from aerial mycelium.*

FIGS. 28 TO 30. Polyporus dryophilus. FIG. 28. *Hypha from advancing zone.* FIG. 29. *Pale aerial hypha.* FIG. 30. *Brown aerial hypha.*

FIGS. 31 TO 35. Polyporus dryophilus *var.* vulpinus. FIG. 31. *Hypha from advancing zone.* FIG. 32. *Aerial hypha.* FIG. 33. *Hyphae from skinlike layer.* FIG. 34. *Basidia.* FIG. 35. *Basidiospores.*

FIGS. 36 TO 39. Polyporus fibrillosus. FIG. 36. *Hyphae from advancing zone.* FIG. 37. *Aerial hypha.* FIG. 38. *Basidia and cystidium.* FIG. 39. *Basidiospores.*

FIGS. 40 to 41. Polyporus fragilis. FIG. 40. *Hyphae from advancing zone.* FIG. 41. *Hyphal segment from aerial mycelium.*

FIGS. 42 TO 46. Polyporus frondosus. FIG. 42. *Hyphae from advancing zone.* FIG. 43. *Fiber hypha.* FIG. 44. *Chlamydospores.* FIG. 45. *Basidia.* FIG. 46. *Basidiospores.*

FIGS. 47 TO 51. Polyporus fumosus. FIG. 47. *Hyphae from advancing zone.* FIG. 48. *Hyphal segment from aerial mycelium.* FIG. 49. *Chlamydospores.* FIG. 50. *Basidium.* FIG. 51. *Basidiospores, ×800.*

FIGS. 52 TO 54. Polyporus galactinus. FIG. 52. *Hyphae from advancing zone.* FIG. 53. *Aerial hypha.* FIG. 54. *Chlamydospores.*

PLATE X

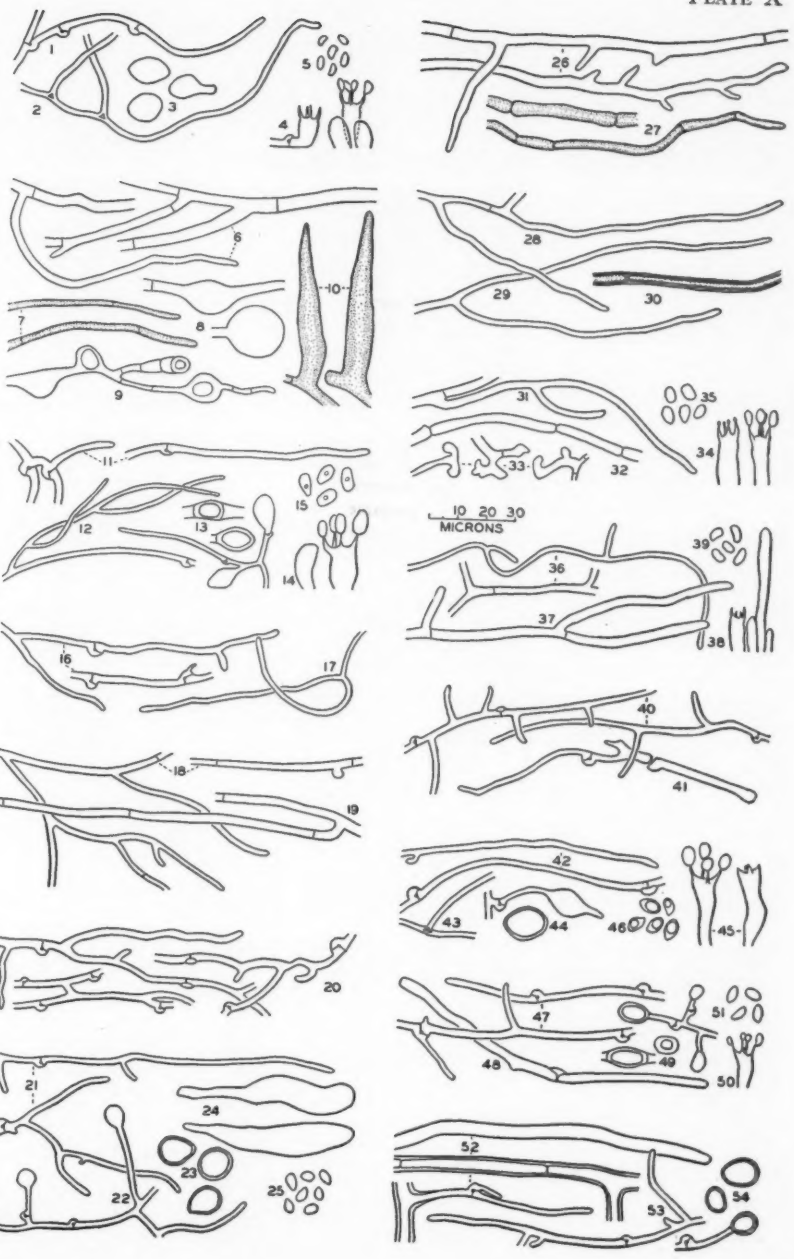
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PLATE XI

FIGS. 1 TO 15. *Cultures grown on malt agar in the dark.*

FIG. 1. Polyporus galactinus, *F3494, two weeks old.*
FIG. 2. Polyporus gilvus, *F1704, five weeks old.*
FIG. 3. Polyporus glomeratus, *F3491, six weeks old.*
FIG. 4. Polyporus graveolens, *F2954, four weeks old.*
FIG. 5. Polyporus guttulatus, *F638, four weeks old.*
FIG. 6. Polyporus hirsutus, *F1319, two weeks old.*
Fig. 7. Polyporus mollis, *F6818, four weeks old.*
Fig. 8. Polyporus montanus, *F8268, six weeks old.*
FIG. 9. Polyporus obtusus, *F6798, six weeks old.*
FIG. 10. Polyporus palustris, *F2964, four weeks old.*
FIG. 11. Polyporus pargamenus, *F8016, four weeks old.*
FIG. 12. Polyporus pubescens, *F3058, two weeks old.*
FIG. 13. Polyporus radiatus, *10207, four weeks old.*
FIG. 14. Polyporus resinosus, *F2063, two weeks old.*
FIG. 15. Polyporus rutilans, *11607, four weeks old.*

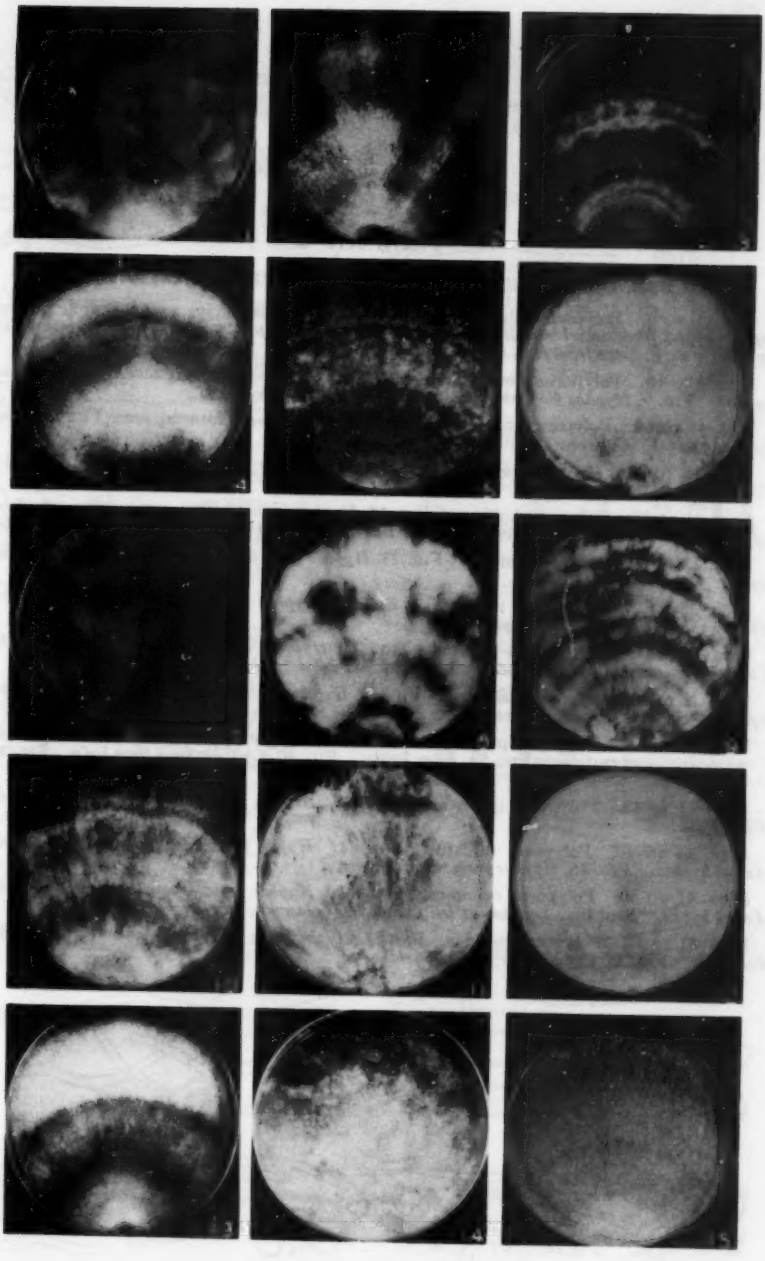

PLATE XII

FIGS. 1 TO 54. *All ×455, except Figs. 16, 17, 21, 22, 35, 36, ×800.*

FIGS. 1 TO 6. Polyporus gilvus. FIG. 1. *Hyphae from advancing zone.* FIG. 2. *Nodose-septate hypha from aerial mycelium.* FIG. 3. *Pale aerial hypha.* FIG. 4. *Dark brown aerial hypha.* FIG. 5. *Setae from fruit body.* FIG. 6. *Basidiospores.*

FIGS. 7 TO 10. Polyporus glomeratus. FIG. 7. *Hypha from advancing zone.* FIG. 8. *Aerial hyphae.* FIG. 9. *Hyphae from skinlike layer.* FIG. 10. *Setal hypha.*

FIGS. 11 TO 14. Polyporus graveolens. FIG. 11. *Hypha from advancing zone.* FIG. 12. *Fiber hypha.* FIG. 13. *Cuticular cells.* FIG. 14. *Oidia.*

FIGS. 15 TO 17. Polyporus guttulatus. FIG. 15. *Hyphae from advancing zone.* FIG. 16. *Conidiophores, ×800.* FIG. 17. *Conidia, ×800.*

FIGS. 18 TO 22. Polyporus hirsutus. FIG. 18. *Hyphae from advancing zone.* FIG. 19. *Fiber hypha.* FIG. 20. *Chlamydospores.* FIG. 21. *Basidium, ×800.* FIG. 22. *Basidiospores, ×800.*

FIGS. 23 TO 24. Polyporus mollis. FIG. 23. *Hyphae from advancing zone.* FIG. 24. *Aerial hypha.*

FIGS. 25 TO 27. Polyporus montanus. FIG. 25. *Hyphae from advancing zone.* FIG. 26. *Fiber hyphae.* FIG. 27. *Chlamydospores.*

FIGS. 28 TO 31. Polyporus obtusus. FIG. 28. *Hypha from advancing zone.* FIG. 29. *Chlamydospores.* FIG. 30. *Aerial hypha.* FIG. 31. *Fiber hypha.*

FIGS. 32 TO 36. Polyporus palustris. FIG. 32. *Hypha from advancing zone.* FIG. 33. *Fiber hyphae.* FIG. 34. *Chlamydospores.* FIG. 35. *Basidia, ×800.* FIG. 36. *Basidiospores, ×800.*

FIGS. 37 TO 41. Polyporus pargamenus. FIG. 37. *Hypha from advancing zone.* FIG. 38. *Capitate incrusted cystidia.* FIG. 39. *Fiber hypha.* FIG. 40. *Cystidia from fruit body.* FIG. 41. *Basidiospores.*

FIGS. 42 TO 43. Polyporus pubescens. FIG. 42. *Hypha from advancing zone.* FIG. 43. *Fiber hyphae.*

FIGS. 44 TO 46. Polyporus radiatus. FIG. 44. *Hypha from advancing zone.* FIG. 45. *Aerial hyphae.* FIG. 46. *Hyphae from skinlike layer.*

FIGS. 47 TO 50. Polyporus resinosus. FIG. 47. *Hyphae from advancing zone.* FIG. 48. *Aerial hypha.* FIG. 49. *Lactiferous cell.* FIG. 50. *Chlamydospores.*

FIGS. 51 TO 54. Polyporus rutilans. FIG. 51. *Hypha from advancing zone.* FIG. 52. *Conidiophores.* FIG. 53. *Conidia.* FIG. 54. *Basidia.*

PLATE XII

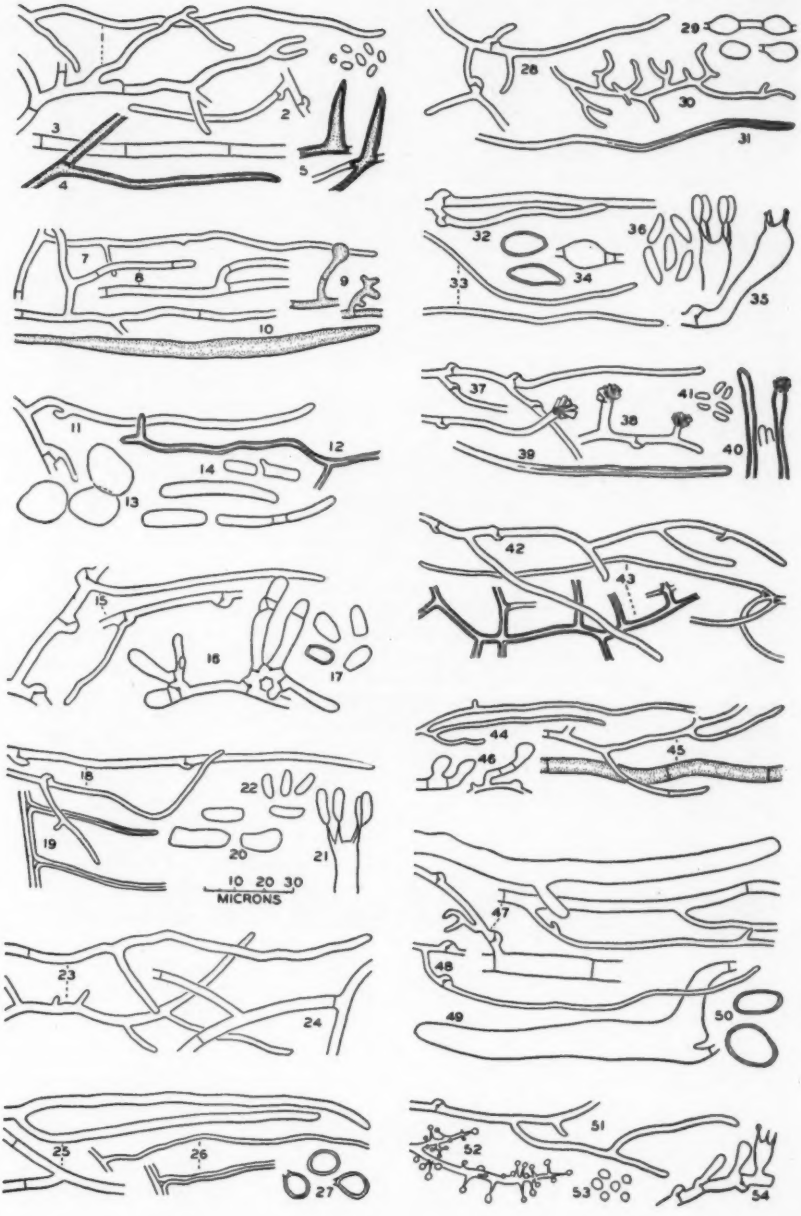
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PLATE XIII

FIGS. 1 TO 12. *Cultures grown on malt agar in the dark.*

FIG. 1. Polyporus Schweinitzii, *9420, four weeks old.*
FIG. 2. Polyporus semipileatus, *F7335, six weeks old.*
FIG. 3. Polyporus squamosus, *10789, six weeks old.*
FIG. 4. Polyporus subcartilagineus, *9417, four weeks old.*
FIG. 5. Polyporus sulphureus, *F3474, two weeks old.*
FIG. 6. Polyporus tuberaster, *F6623, six weeks old.*
FIG. 7. Polyporus Tulipiferae, *F8049, two weeks old.*
FIG. 8. Polyporus umbellatus, *F7336, six weeks old.*
FIG. 9. Polyporus versicolor, *8183, three weeks old.*
FIG. 10. Polyporus volvatus, *F6814, four weeks old.*
FIG. 11. Polyporus zonatus, *F7338, one week old.*
FIG. 12. Polyporus zonatus, *F7390, six weeks old.*

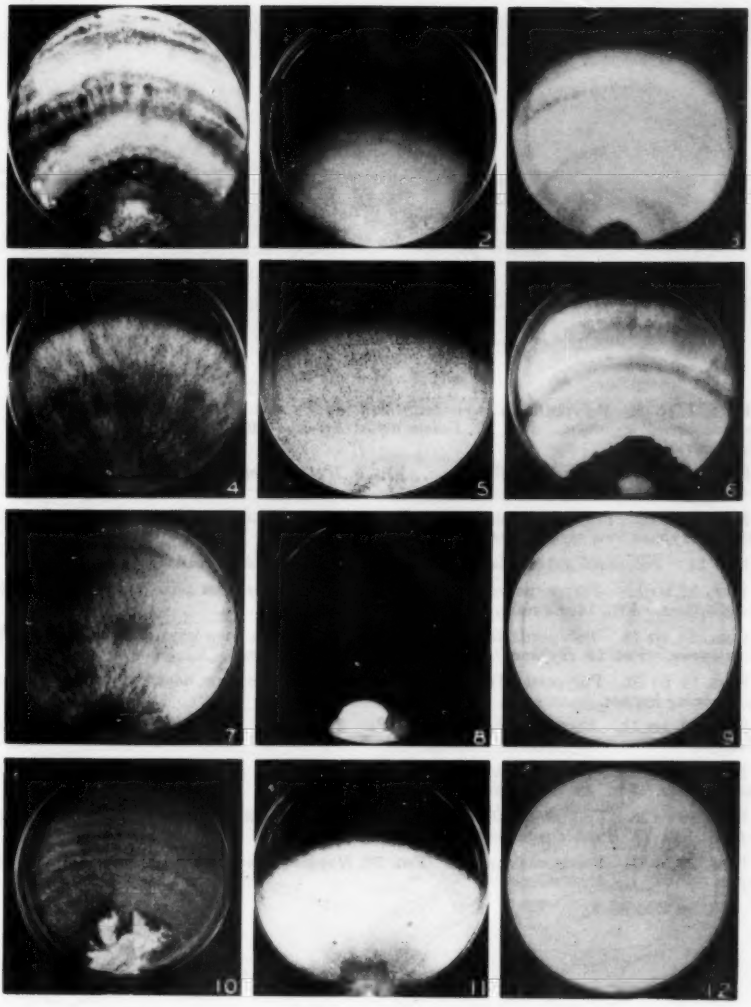
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PLATE XIV

FIGS. 1 TO 31. *All ×455.*

FIGS. 1 TO 5. Polyporus Schweinitzii. FIG. 1. *Hyphae from advancing zone.* FIG. 2. *Hyaline aerial mycelium.* FIG. 2. *Yellow aerial hypha.* FIG. 4. *Chlamydospores.* FIG. 5. *Brown aerial hypha.*

FIGS. 6 TO 7. Polyporus semipileatus. FIG. 6. *Hyphae from advancing zone.* FIG. 7. *Contorted incrusted hyphal tips.*

FIGS. 8 TO 10. Polyporus squamosus. FIG. 8. *Hypha from advancing zone.* FIG. 9. *Oidia.* FIG. 10. *Hyphae from skinlike area.*

FIG. 11. Polyporus subcartilagineus. FIG. 11. *Hyphae from advancing zone.*

FIGS. 12 TO 15. Polyporus sulphureus. FIG. 12. *Hyphae from advancing zone.* FIG. 13. *Conidiophore.* FIG. 14. *Conidia.* FIG. 15. *Chlamydospores.*

FIGS. 16 TO 18. Polyporus tuberaster. FIG. 16. *Hypha from advancing zone.* FIG. 17. *Fiber hypha.* FIG. 18. *Hyphae from pseudoparenchymatous layer.*

FIGS. 19 TO 20. Polyporus Tulipiferae. FIG. 19. *Hyphae from advancing zone.* FIG. 20. *Nonstaining hyphae.*

FIGS. 21 TO 22. Polyporus umbellatus. FIG. 21. *Hyphae from advancing zone.* FIG. 22. *Oidia.*

FIGS. 23 TO 25. Polyporus versicolor. FIG. 23. *Hyphae from advancing zone.* FIG. 24. *Fiber hyphae.* FIG. 25. *Chlamydospores.*

FIGS. 26 TO 28. Polyporus volvatus. FIG. 26. *Hyphae from advancing zone.* FIG. 27. *Fiber hypha.* FIG. 28. *Hyphae with swellings.*

FIGS. 29 to 31. Polyporus zonatus. FIG. 29. *Hyphae from advancing zone.* FIG. 30. *Fiber hypha.* FIG. 31. *Chlamydospores.*

PLATE XIV

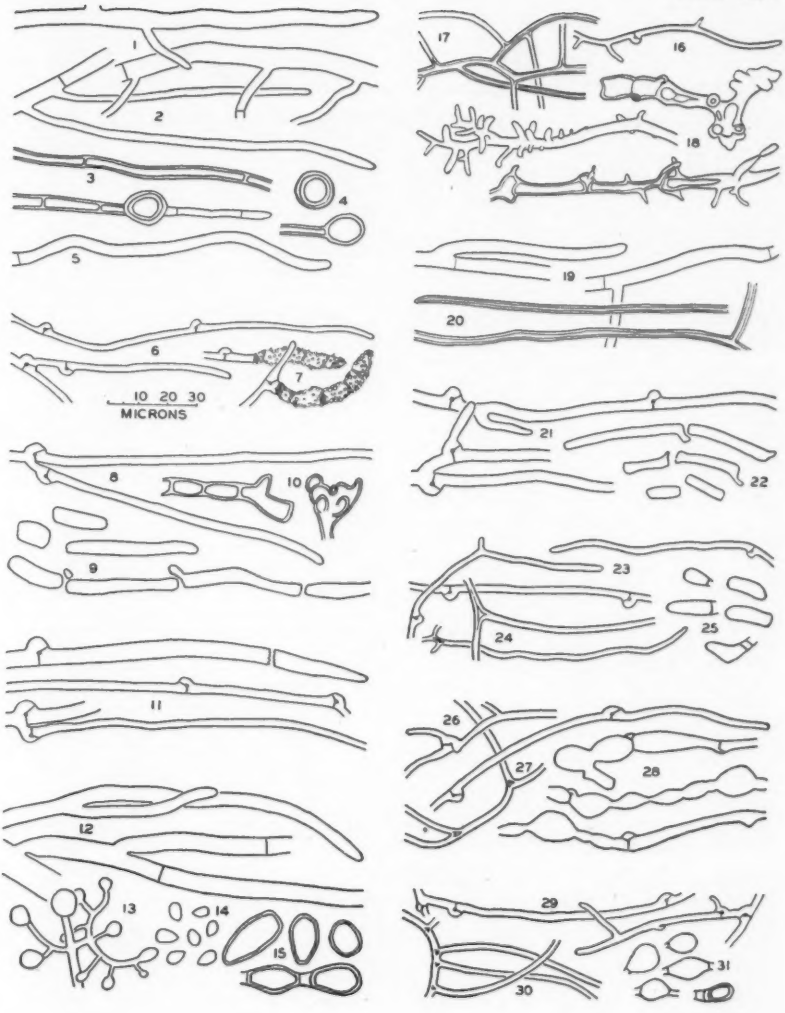
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PLATE XV

FIGS. 1 TO 15. *Cultures grown on malt agar in the dark.*

FIG. 1. Poria albipellucida, *11692, two weeks old.*
FIG. 2. Poria asiatica, *17118, six weeks old.*
FIG. 3. Poria carbonica, *8269, five weeks old.*
FIG. 4. Poria ferrea, *9254, five weeks old.*
FIG. 5. Poria ferrugineo-fusca, *F7340, four weeks old.*
FIG. 6. Poria ferruginosa, *11253, six weeks old.*
FIG. 7. Poria monticola, *9251, six weeks old.*
FIG. 8. Poria obliqua, *F7449, six weeks old.*
FIG. 9. Poria punctata, *F1402, four weeks old.*
FIG. 10. Poria rufa, *16615, six weeks old.*
FIG. 11. Poria subacida, *F598, two weeks old.*
FIG. 12. Poria tsugina, *9243, six weeks old.*
FIG. 13. Poria Vaillantii, *11740, six weeks old.*
FIG. 14. Poria Weirii, *9323, two weeks old.*
FIG. 15. Poria xantha, *16088, four weeks old.*

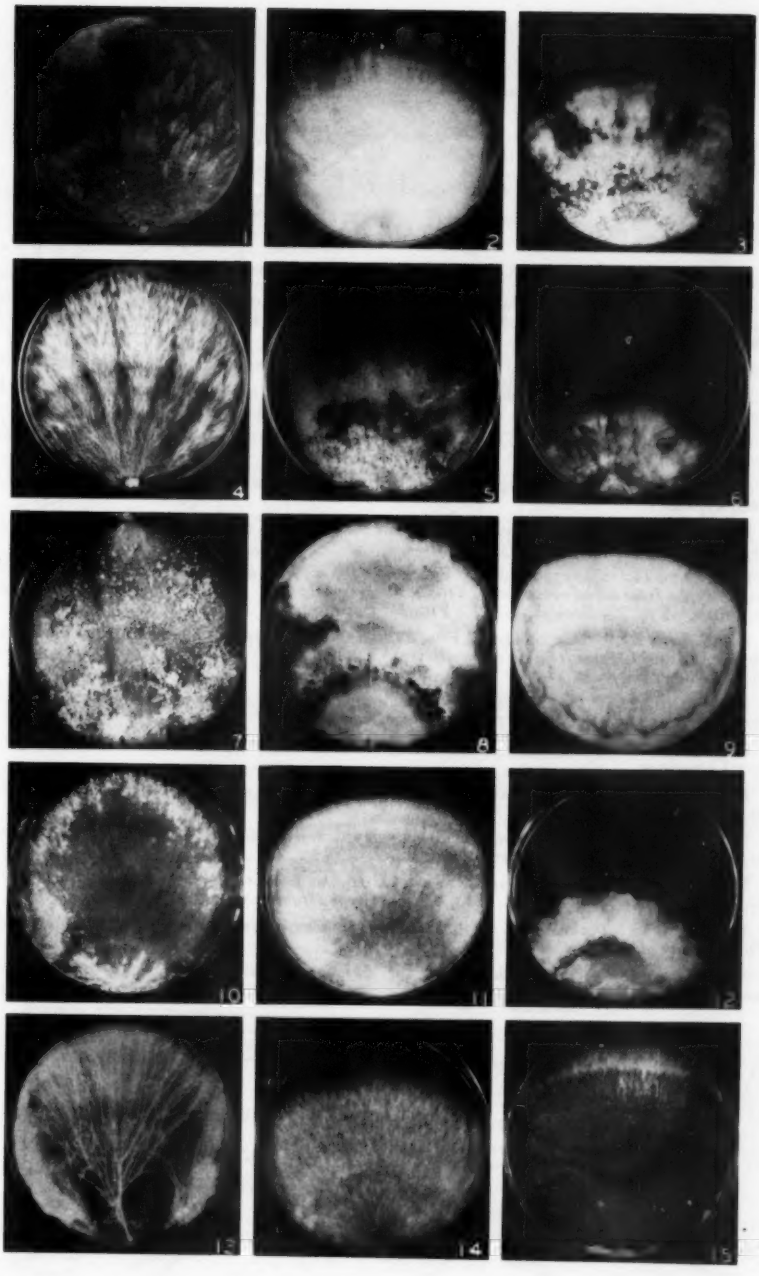
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PLATE XVI

FIGS. 1 TO 48. *All ×455, except Figs. 23 and 24, ×800.*

FIGS. 1 TO 5. Poria albipellucida. FIG. 1. *Hypha from advancing zone.* FIG. 2. *Thick-walled aerial hyphae.* FIG. 3. *Nodose-septate aerial hyphae.* FIG. 4. *Chlamydospores.* FIG. 5. *Oidia.*

FIGS. 6 TO 7. Poria asiatica. FIG. 6. *Hyphae from advancing zone.* FIG. 7. *Chlamydospores.*

FIGS. 8 TO 11. Poria carbonica. FIG. 8. *Hyphae from advancing zone.* FIG. 9. *Hypha from aerial mycelium.* FIG. 10. *Conidiophores and conidia.* FIG. 11. *Chlamydospores.*

FIGS. 12 TO 13. Poria ferrea. FIG. 12. *Hypha from advancing zone.* FIG. 13. *Hyphae from aerial mycelium.*

FIGS. 14 TO 15. Poria ferrugineo-fusca. FIG. 14. *Hyphae from advancing zone.* FIG. 15. *Setal hyphae.*

FIGS. 16 TO 18. Poria ferruginosa. FIG. 16. *Hypha from advancing zone.* FIG. 17. *Aerial hyphae showing anastomosis.* FIG. 18. *Setae.*

FIGS. 19 TO 24. Poria monticola. FIG. 19. *Hyphae from advancing zone.* FIG. 20. *Thick-walled hypha from aerial mycelium.* FIG. 21. *Chlamydospores.* FIG. 22. *Hypha from submerged mycelium.* FIG. 23. *Basidia, ×800.* FIG. 24. *Basidiospores, ×800.*

FIGS. 25 TO 29. Poria obliqua. FIG. 25. *Hypha from advancing zone.* FIG. 26. *Aerial hyphae.* FIG. 27. *Setae from aerial mycelium.* FIG. 28. *Basidia and setae from fruiting surface.* FIG. 29. *Basidiospores.*

FIGS. 30 TO 32. Poria punctata. FIG. 30. *Hyphae from advancing zone.* FIG. 31. *Brown aerial hyphae.* FIG. 32. *Hypha from submerged mycelium.*

FIGS. 33 TO 34. Poria rufa. FIG. 33. *Hyphae from advancing zone.* FIG. 34. *Hypha from aerial mycelium.*

FIGS. 35 TO 36. Poria subacida. FIG. 35. *Hyphae from advancing zone.* FIG. 36. *Fiber hyphae.*

FIGS. 37 TO 39. Poria tsugina. FIG. 37. *Hyphae from advancing zone.* FIG. 38. *Aerial hyphae.* FIG. 39. *Hyphae from crustose area.*

FIGS. 40 TO 42. Poria Vaillantii. FIG. 40. *Hypha from advancing zone.* FIG. 41. *Broad hypha from submerged mycelium.* FIG. 42. *Fiber hypha from fruit body.*

FIGS. 43 TO 45. Poria Weirii. FIG. 43. *Hypha from advancing zone.* FIG. 44. *Aerial hyphae.* FIG. 45. *End of setal hypha.*

FIGS. 46 TO 48. Poria xantha. FIG. 46. *Hyphae from advancing zone.* FIG. 47. *Thick-walled hyphae.* FIG. 48. *Chlamydospores.*

PLATE XVI

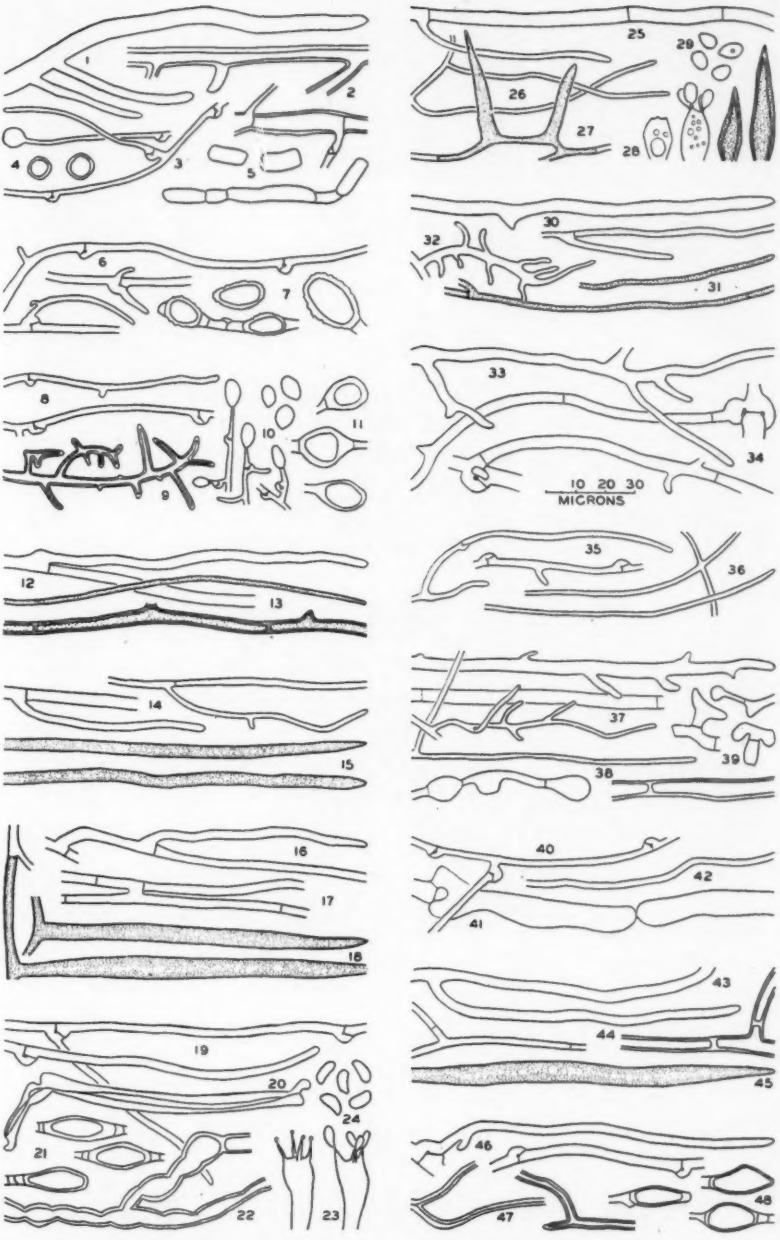
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PLATE XVII

FIGS. 1 TO 12. *Cultures grown on malt agar in the dark.*

FIG. 1. Schizophyllum commune, *F2961, four weeks old.*
FIG. 2. Stereum abietinum, *16091, six weeks old.*
FIG. 3. Stereum Murraii, *F1362, six weeks old.*
FIG. 4. Stereum sanguinolentum, *9330, four weeks old.*
FIG. 5. Trametes americana, *8189, six weeks old.*
FIG. 6. Trametes americana, *11789, six weeks old.*
FIG. 7. Trametes heteromorpha, *11991, six weeks old.*
FIG. 8. Trametes sepium, *11987, four weeks old.*
FIG. 9. Trametes serialis, *10916, four weeks old.*
FIG. 10. Trametes suaveolens, *F3523, four weeks old.*
FIG. 11. Trametes tenuis, *9265, six weeks old.*
FIG. 12. Trametes variiformis, *16098, six weeks old.*

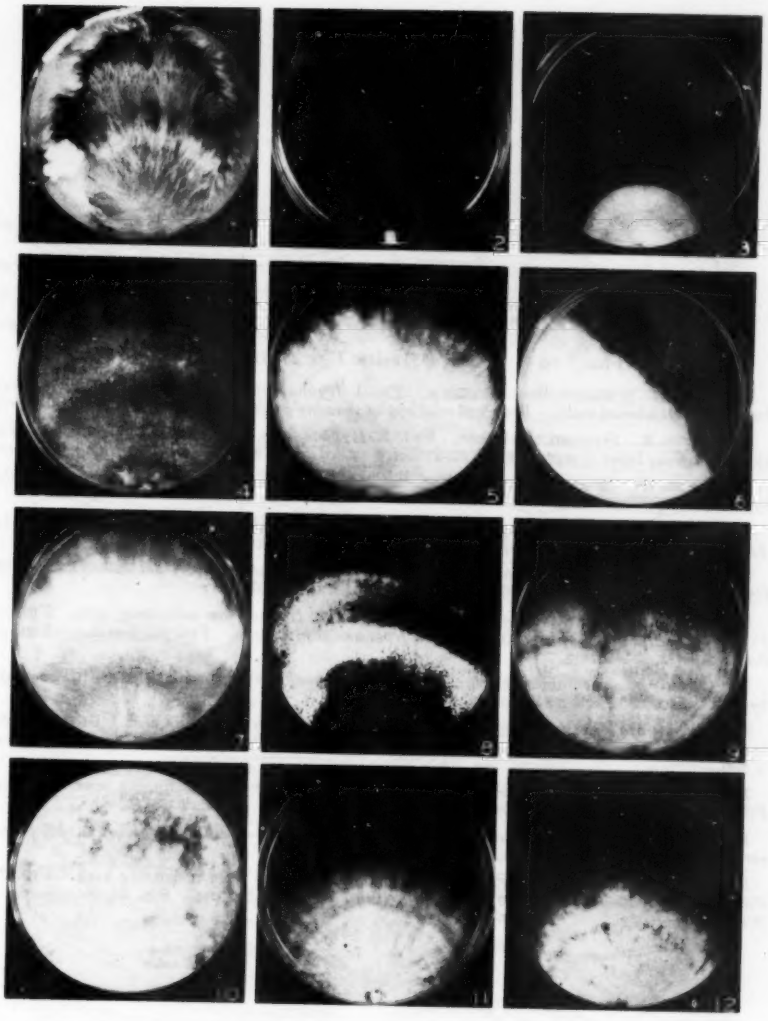


PLATE XVIII

FIGS. 1 TO 41. *All ×455, except Figs. 23, 31, 42, ×800.*

FIGS. 1 TO 4. Schizophyllum commune. FIG. 1. *Hypha from advancing zone.* FIG. 2. *Aerial hyphae with thickened walls.* FIG. 3. *Aerial hypha showing projections.* FIG. 4. *Chlamydospores.*

FIGS. 5 TO 8. Stereum abietinum. FIG. 5. *Hyphae from advancing zone.* FIG. 6. *Aerial hyphae showing types of septation.* FIG. 7. *Thick-walled aerial hyphae.* FIG. 8. *Chlamydospores.*

FIGS. 9 TO 10. Stereum Murraii. FIG. 9. *Hyphae from advancing zone.* FIG. 10. *Fiber hyphae.*

FIGS. 11 TO 14. Stereum sanguinolentum. FIG. 11. *Hyphae from advancing zone.* FIG. 12. *Aerial hyphae.* FIG. 13. *Much-branched aerial hypha.* FIG. 14. *Brown conducting cells.*

FIGS. 15 TO 18. Trametes americana. FIG. 15. *Hyphae from diploid colony.* FIG. 16. *Hypha from haploid colony.* FIG. 17. *Oidia.* FIG. 18. *Chlamydospores.*

FIGS. 19 TO 23. Trametes heteromorpha. FIG. 19. *Hypha from advancing zone.* FIG. 20. *Fiber hyphae.* FIG. 21. *Thick-walled hypha from aerial mycelium.* FIG. 22. *Basidia.* FIG. 23. *Basidiospores, ×800.*

FIGS. 24 TO 26. Trametes sepium. FIG. 24. *Hyphae from advancing zone.* FIG. 25. *Fiber hyphae.* FIG. 26. *Thick-walled aerial hypha.*

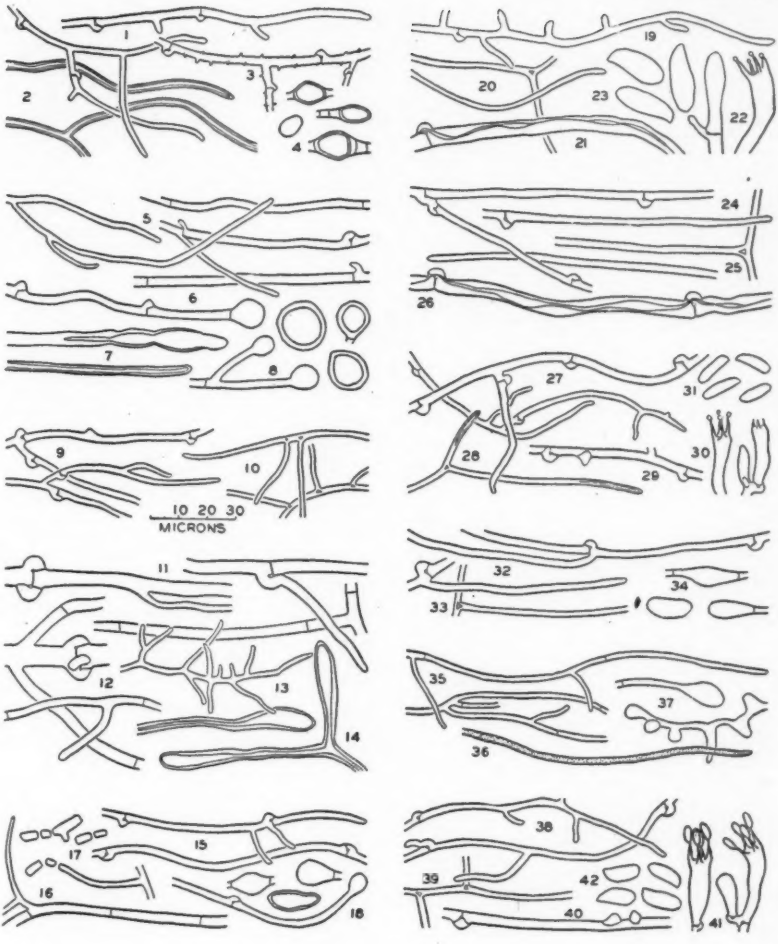
FIGS. 27 TO 31. Trametes serialis. FIG. 27. *Hyphae from advancing zone.* FIG. 28. *Fiber hypha.* FIG. 29. *Hypha from aerial mycelium.* FIG. 30. *Basidia.* FIG. 31. *Basidiospores, ×800.*

FIGS. 32 TO 34. Trametes suaveolens. FIG. 32. *Hyphae from advancing zone.* FIG. 33. *Fiber hypha.* FIG. 34. *Chlamydospores.*

FIGS. 35 TO 37. Trametes tenuis. FIG. 35. *Hyphae from advancing zone.* FIG. 36. *Brown aerial hypha.* FIG. 37. *Swollen cells on aerial hyphae.*

FIGS. 38 TO 42. Trametes variiformis. FIG. 38. *Hyphae from advancing zone.* FIG. 39. *Fiber hypha.* FIG. 40. *Hypha from aerial mycelium.* FIG. 41. *Basidia.* FIG. 42. *Basidiospores, ×800.*

PLATE XVIII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CANADIAN JOURNAL OF RESEARCH

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